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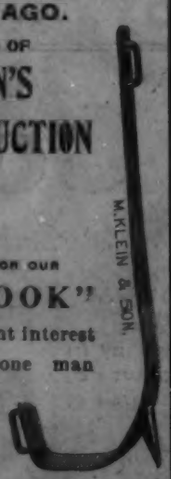

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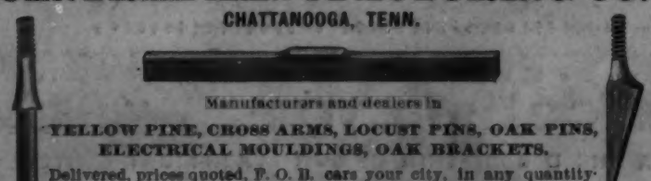

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AN ILLUSTRATED MONTHLY TELEPHONE JOURNAL

VOL. I. CHICAGO, MAY, 1901. No. 5.

MODERN TELEPHONE ENGINEERING.

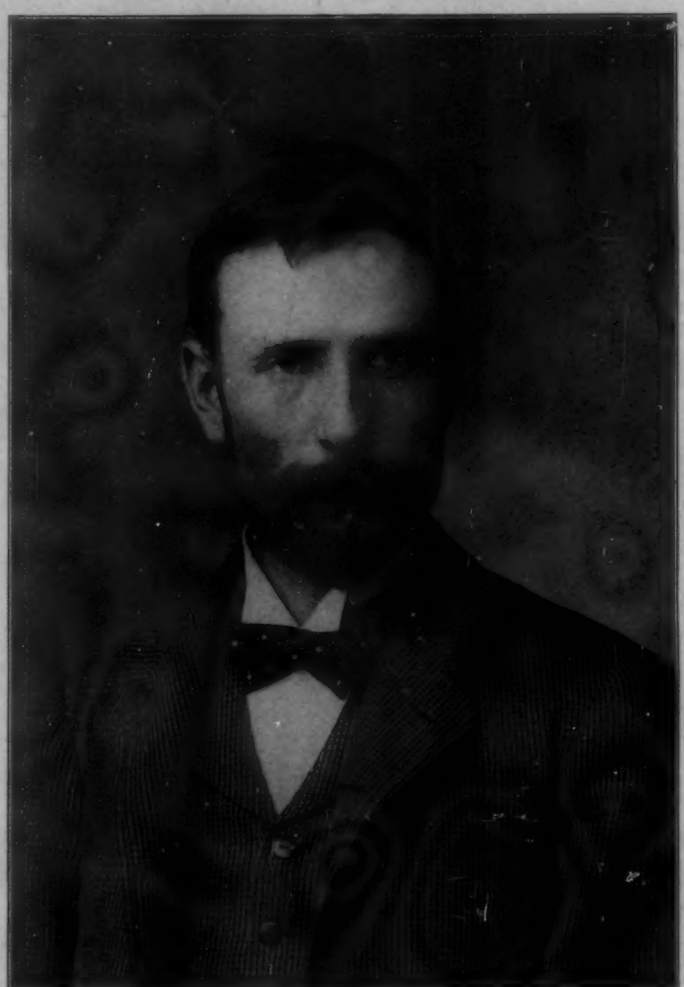
BY KEMPSTER B. MILLER, M. E.

Paper Read Before the New York Electrical Society.

Mr. President and gentlemen of the New York Electrical Society:

The subject which you have assigned to me, "Modern Telephone Engineering," is one of such breadth that only portions of it can be treated in a single evening, and those portions not with as great an amount of detail as I would desire.

After careful consideration, I have concluded that the subject matter which is most likely to interest the greatest number of those present is a discussion of a few of the engineering problems arising in planning a telephone exchange, and also a description of some of the methods and means employed in what may be considered modern telephone practice. Time will not permit me to deal with the various items in detail, and therefore these remarks should be regarded in many cases rather as suggestions than as complete treatments of the various points.



KEMPSTER B. MILLER.

The statements which I will make in the course of the evening will relate to what I believe to be good telephone practice, regardless of whether it is the practice of the Bell or of the independent companies. The circuits shown are those of the Bell Company, and the apparatus mostly that of the Kellogg Switchboard & Supply Company, with which company I am connected. I trust that I may be pardoned for appearing partial to the apparatus of this latter company; but, in the first place, my brethren under the wing of the Bell Company have not exhibited an undue amount of enthusiasm in the matter of furnishing me with cuts and data thereon. In the second place, I have been closely identified with the design and the manufacture of the Kellogg apparatus and am therefore better able to talk of it. In the third place, I think that most of the telephone engineers here are perhaps as familiar, if not more so than I am, with the apparatus of the Bell Company, and therefore will be more interested in that of another make. Be this as it may, whatever methods, circuits and apparatus are described will be typical of the telephone art as it exists to-day.

The first problem arising when a telephone exchange is to be installed in a large city is that of the number, size and location of the central office or offices. The proper solution of this problem depends in all cases upon local conditions and can be attained only after much consideration and calculation.

If the cheapest were the best, the telephone engineer would experience comparatively little difficulty in exactly determining the location of the telephone office or offices, as well as the boundaries of the office districts in any city, after having canvassed the communities and ascertained the topographical location of the present and prospective subscribers. The most important consideration is that of the quality of service to be rendered. This factor, "quality of service," can not be expressed in dollars and cents; it must be left to the good judgment of the engineer to so construct the telephone plant that the demands made by the public are satisfied without making the plant so expensive as to be an unprofitable investment.

Other matters to be considered in the preliminary layout of a system are:

Annual cost of operation, including salaries of operators and the cost of current supply; fixed charges and rent interest and depreciation on the office equipment, interest and depreciation on the wire plant, interest and depreciation on the subscribers' apparatus, and annual cost of maintenance. These factors, unlike the first mentioned, are subject to predetermination with a fair degree of exactness.

A brief discussion of each of these various factors as to their bearing on the number and location of offices will probably be of interest.

I think it is a well established fact that the best telephone service can be given where all the lines of the subscribers in a city run to a single exchange and are there handled by a single multiple switchboard. By this means all calls for connections by any subscriber may be handled by a single operator. Where the number of subscribers, however, is too great to be connected to a single switchboard, or where the distribution is such as to naturally group them about well defined and remote centers, a greater number than

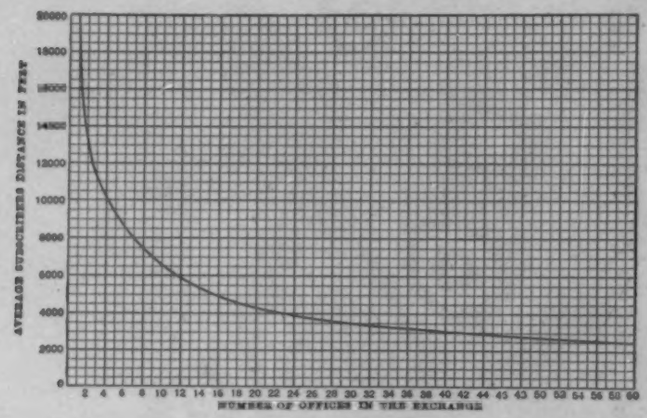


FIG. 1—DOMMERQUE CURVE.

one exchange must be installed and lines provided between them for connecting the subscribers in the different exchanges. Such lines are called trunking lines, in distinction to subscribers' lines, which connect the subscriber with the central office.

In most cases where trunking is necessary, most calls have to be trunked. I believe the percentage of trunked calls to total calls for Greater New York is in the neighborhood of eighty. A connection made over a trunk line necessarily occupies more time and thereby renders the service a little slower. In fact, the aggregate time required for connection over a trunk line is practically twice as great as where accomplished by a single operator in a multiple board. The fact that two operators necessarily handle a trunk connection necessarily increases the liability to error in making the connection, and therefore pro-

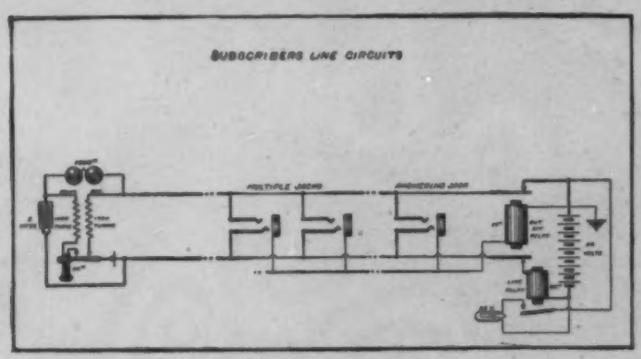


FIG. 2—LINE CIRCUIT.

duces less satisfactory service. The trunking apparatus and circuits, in order not only to transmit speech, but to convey the requisite signals between the operators, are necessarily more complex than subscribers' line circuits; and thereby a greater liability to trouble exists than where no trunks are required.

So far, therefore, as the question of quality of service is concerned, there can be no question but that a single large office serving all of the subscribers in a given city is best.

Again, if we consider only operating expense, a single office serving the entire city is best. First, because in a single office the total number of operators required is a minimum (it has been amply proven by experience that this is so); second, in a trunking system the number of higher paid persons than operators will be greatly increased, as there will be for instance, a manager, a wire chief, a chief operator, etc., for each of the different offices; third, the item of current supply is naturally higher with several offices than with a single large one, as the power system requires more current on account of the greater amount of apparatus and also on account of the machinery being split up into smaller units and working with less efficiency.

The item of fixed charges and rent includes the salaries paid to the general management, the business and engineering offices, as well as rent. The former items should not differ materially whether one office or a greater number is used. The question of rent, however, is a little more complex and must be accurately determined for each particular city. It will vary from 50 cents to $2 per annum for every square foot of floor space. Where a single office is used this is necessarily located somewhere in the center of the city where rent is highest. Where a number of offices are used, the offices will not be in the center of the city, but will of necessity be at points densely populated. The probabilities are that the rental, which will also include light, heat, elevator service and janitor service, etc., will be

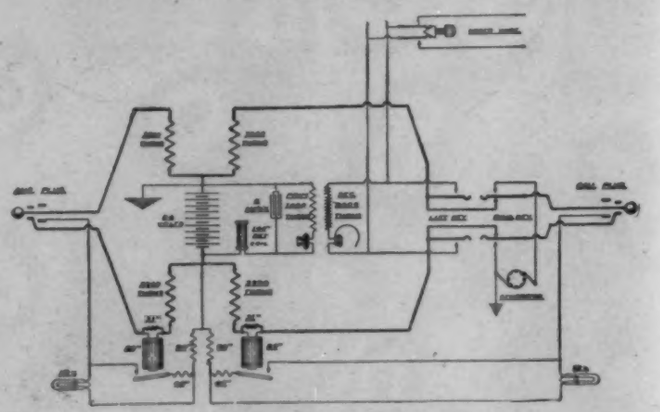


FIG. 3—CORD CIRCUIT.

slightly cheaper for a large office located in the heart of the city than for several smaller offices located in the most densely populated portion of their respective districts.

The interest and depreciation of the office equipment is in most cases smaller for the single office system, for while it is true that a single large multiple board costs more than a number of smaller multiple boards having the same aggregate capacity as the large one, yet the addition of the trunking apparatus to the smaller boards, and the fact that the power plants, managers, wire chief's, monitor's and trouble clerk's desks and similar apparatus are duplicated at each exchange, will probably throw the balance in favor of the single large exchange. This matter, however, would need to be determined for each set of conditions, as it can not be said in all cases the office equipment for a single exchange would be cheaper than that of a greater number of exchanges furnishing service to the same number of subscribers.

All the factors so far considered, that is, the quality of service, the cost of operation, fixed charges and rent, and depreciation on the office equipment seem to lean in favor of the single office, some of them decidedly so, others not so strongly. Against these must be put, in some cases, the interest and depreciation on the wire plant and the item of annual cost of maintenance.

By wire plant is understood everything pertaining to the telephone plant, from the subscriber's premises to that point in the telephone office, or offices, where the lines en-

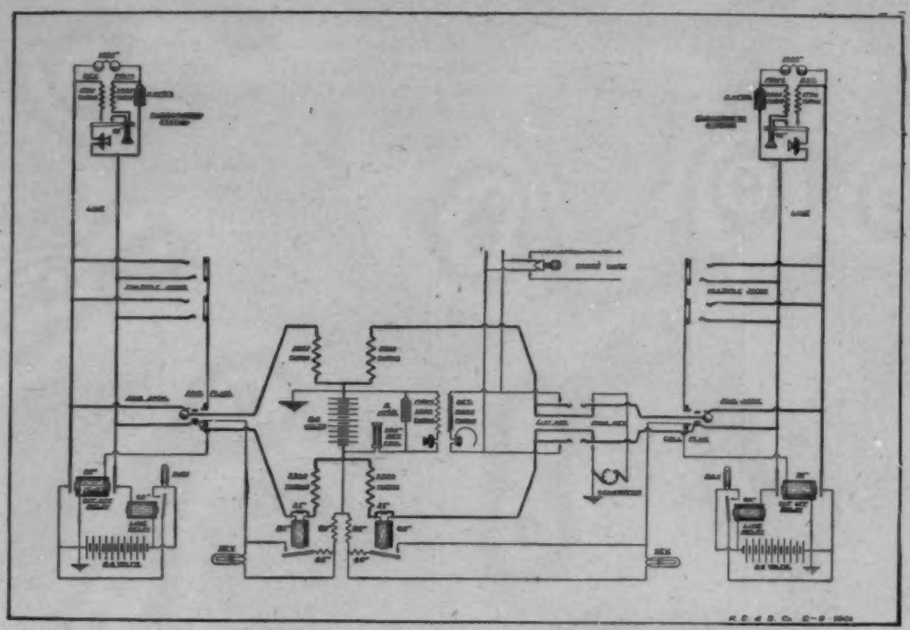


FIG. 4—CIRCUIT BETWEEN TWO LOCAL SUBSCRIBERS' LINES.

ter the terminal heads. It therefore embraces the underground conduits and cables, the pole lines carrying cables or bare lines, together with all necessary apparatus such as manholes, drop wires, etc.

It is easy to see that the average length of subscribers' lines will be greatest when a single office is used, and will steadily decrease as the number of offices is increased. It has been pointed out by Mr. F. J. Dommerque that in a given community the average length of subscribers' lines varies inversely as the square root of the number of offices. In other words, if the average length of subscribers' lines with one office is L, then the average length of subscribers' lines with N offices is approximately $L' = \frac{L}{\sqrt{N}}$. This law is not strictly true, but gives a close approximation. Mr. Dommerque, in planning the re-equipment of the system of the Chicago Telephone Company on an ultimate basis of fifty thousand (50,000) subscribers, found that the average length of line for the city of Chicago, if equipped with one exchange, would be twenty thousand (20,000) feet. From this figure and from the law of variation just stated, the curve shown in Fig. 1 has been plotted, giving the average length of subscribers' line for any greater number of offices up to sixty. It was found that the actual measurements of subscribers' lines for the various proposed layouts for the city of Chicago closely coincided with the figures of this curve, so closely in fact that such a curve was found to be a practically reliable source of information for any number of offices. A similar curve might be plotted for trunk lines and order wires connecting such offices, which curve would, of course, start with a zero ordinate for one office and rapidly rise with the number of offices.

It is interesting to conceive these curves, when carried to their limits; that is, when there were 50,000 central offices for 50,000 subscribers. The curve of subscribers' lines would then have a zero ordinate, while the curve for the trunk lines would have a maximum ordinate which would

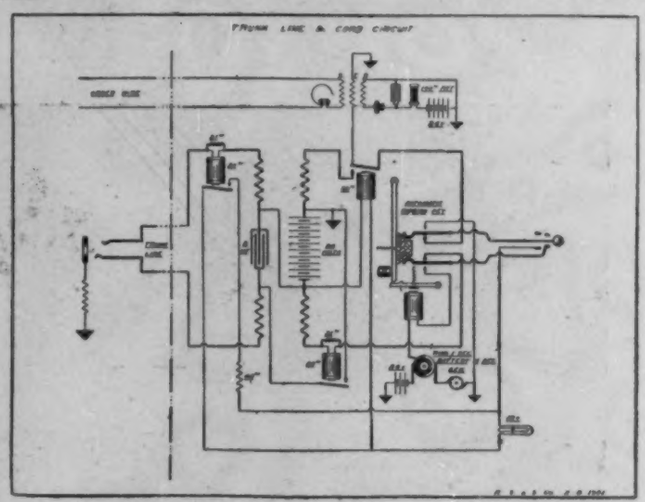
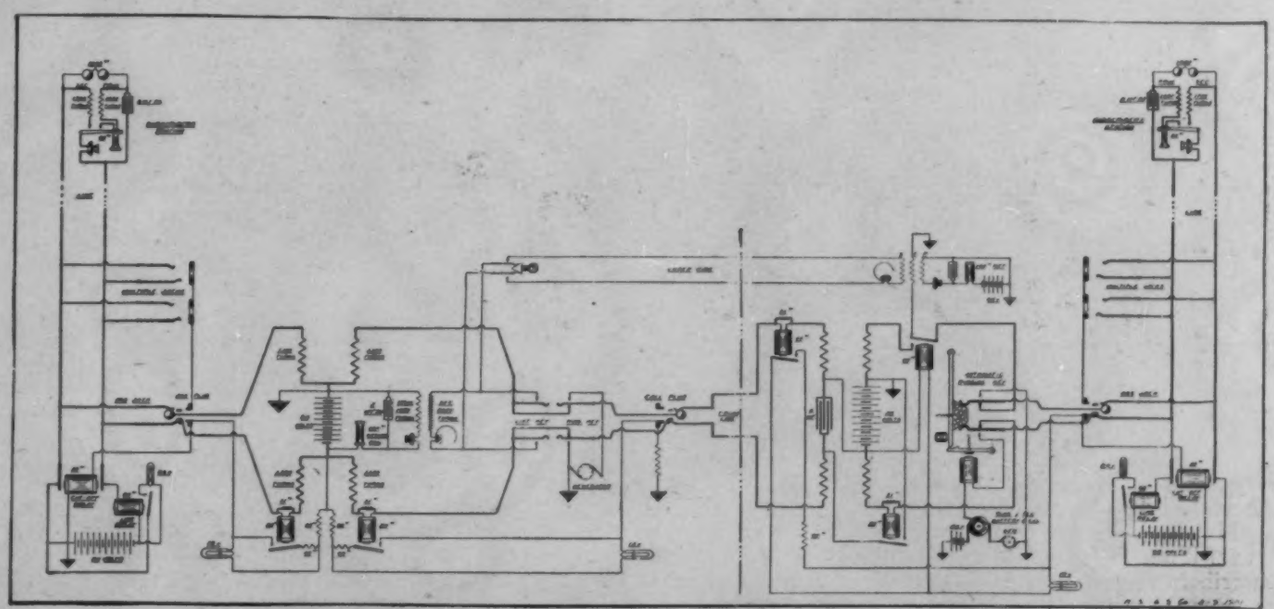


FIG. 5—TRUNK CIRCUIT.



FIGS. 6 AND 7—CIRCUIT BETWEEN TWO SUBSCRIBERS IN DIFFERENT EXCHANGES.

be equal in feet to the distance from one subscriber's station through all of the other subscribers' stations. This means that there would be no subscribers' lines whatever, but that from each subscribers' station there would

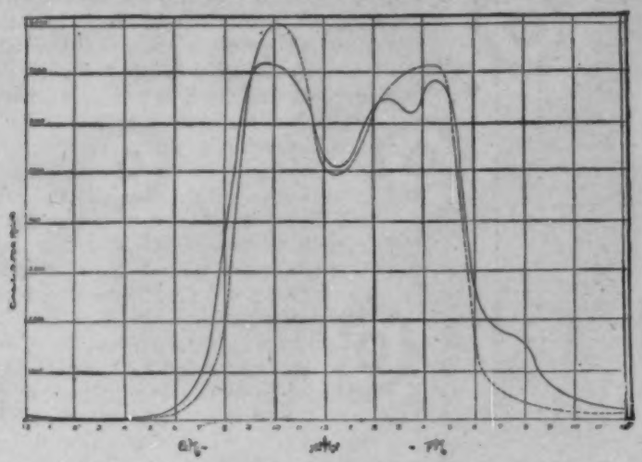


FIG. 8—LOAD CURVE.

be a trunk line corresponding to every one of the 49,999 other stations, as these trunk lines would extend through all stations. We have an actual example of such a system as this in the ordinary house telephone system, where every subscriber has his own central office and where every subscriber's line extends to every other subscriber.

If there is but one exchange in the city, the proper location for it may be found by marking upon the map all of the subscribers present and prospective and then determining the center of gravity of the system, so to speak. This may be readily done by drawing a straight line through the map in such a manner as to have one-half of all the subscribers on one side of it and the other half on the other. In a similar manner another line may be drawn at right angles to the first, bisecting the total number of subscribers, and the intersection of these two lines will probably be fairly close to the proper place for the central office.

A remote group of subscribers, not cut by these two

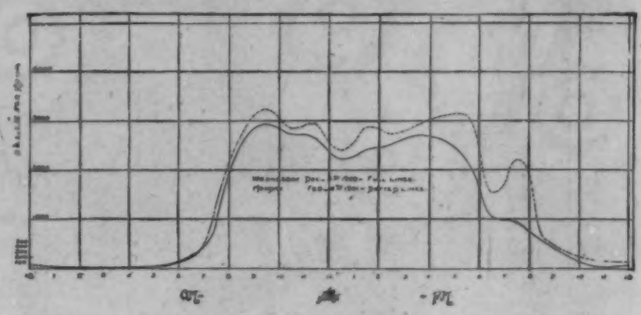


FIG. 9—LOAD CURVE.

lines, would tend to draw the true center of distribution from the point so located toward it. In order to avoid errors from this source, a number of other pairs of bisecting lines should be drawn, the lines of each pair being at right angles. Three such pairs of co-ordinates, 30 degrees apart, would locate three centers, probably close together, and the center of the triangles formed by these centers is a very close approximation to the center of distribution of all the subscribers.

FIG. 10—PARIS EXCHANGE.

With this location determined, it is an easy matter to determine the total average distance of the subscribers from it, and therefore the total wire mileage of the subscribers' lines. With the average subscribers' distances as the base, a curve such as just shown may be plotted, which will show

in a close enough degree of approximation what the average length of subscribers' line would be for any other number of central offices.

If it is found necessary for any reason to divide the system up into office districts, a great amount of care must be taken as to the proper boundaries for these districts. Of

FIG. 11—PITTSBURG EXCHANGE.

Of course, as the number of offices increases, the wire mileage of the trunk lines and order wires increases and figures concerning this must be worked out in consideration of the locations of the various offices and the amount of traffic between them. This latter factor, the traffic between offices, varies greatly according to the kind of districts connected, and it is therefore almost impossible to

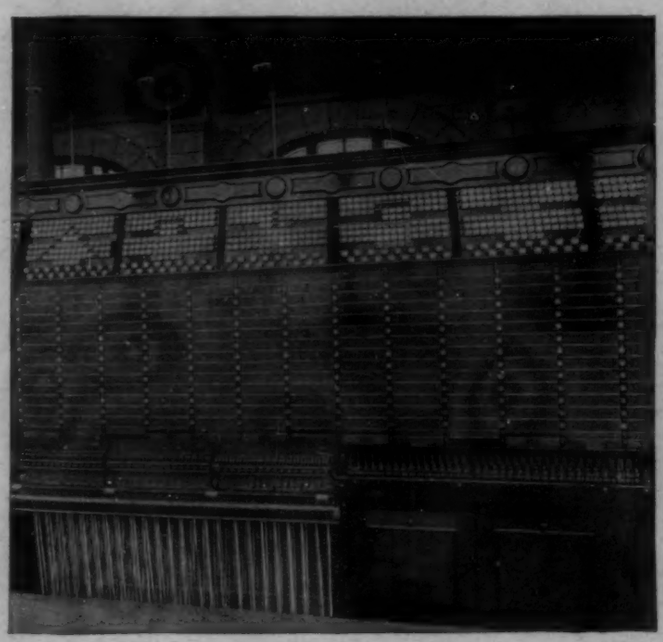


FIG. 12—FRONT OF PARIS EXCHANGE.

give general figures as to the mileage of trunk lines and order wires. It may be said, however, that the statistics of the large cities of this country and Europe show that the trunk and order circuit wire mileage is approximately one-fifth of that of the subscribers' wire-mileage. It is evident that this figure can be used as a basis for laying out new exchanges, for, by the very nature of things, there can be no definite ratio between the two.

course, rivers, water fronts and railroads will frequently aid in the determination of these boundaries. There is frequently a tendency toward the use of large business streets

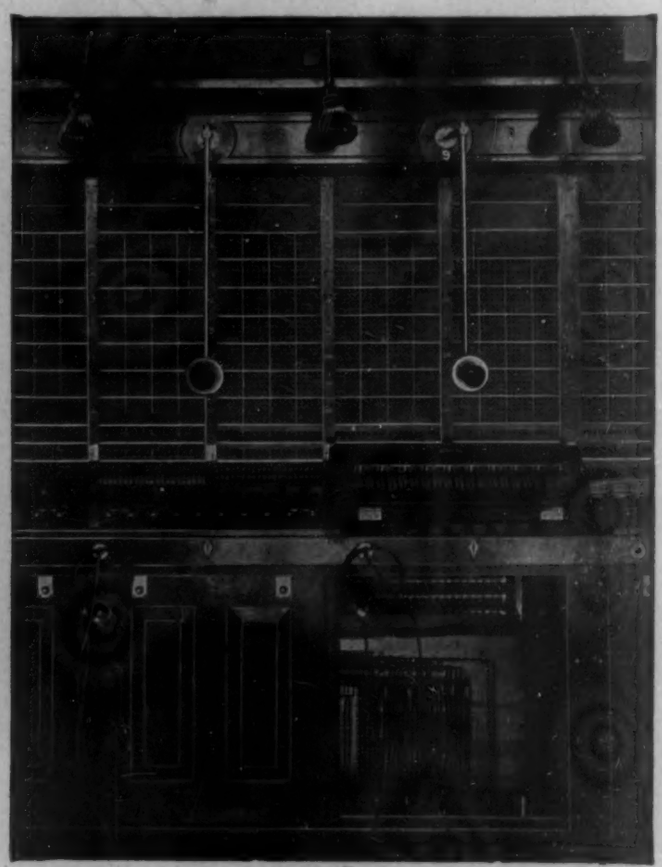


FIG. 14—FRONT OF PITTSBURG SINGLE SECTION.

and thoroughfares as boundary lines between districts, but investigation will show that in many cases this is not good practice, as such streets or thoroughfares should be the

centers of distribution rather than the boundaries of them. Diagonal thoroughfares between offices should be used as trunk line routes rather than boundaries of districts, owing to their directness and to the fact that a large number of subscribers are usually located in their vicinities.

Having decided on the boundaries of the districts, their respective centers may be determined, and between these the most available routes for trunk lines determined.

In figuring the cost of the wire plant for various layouts of a city, it will not do to assume the cost to be in direct proportion to the wire mileage required by the systems using one office, or a greater number, for there is a factor entering the problem which greatly favors the single office, or, I might say, greatly favors the fewer number of offices. This factor is due to the fact that with the single office system, or with the system using few offices, a greater amount, in proportion, of large conduit and cable may be used, and therefore the cost per conduit foot and per mile will be considerably smaller than where a greater number of offices are used.

In general, it may be said that the interest and depreciation on the wire plant decreases as the number of offices increases, and this is the main, and, in fact, practically the only item to offset the advantages of the fewer number of offices or the single office.

The interest and depreciation on the subscribers' apparatus would be the same, whether one or many offices were used.

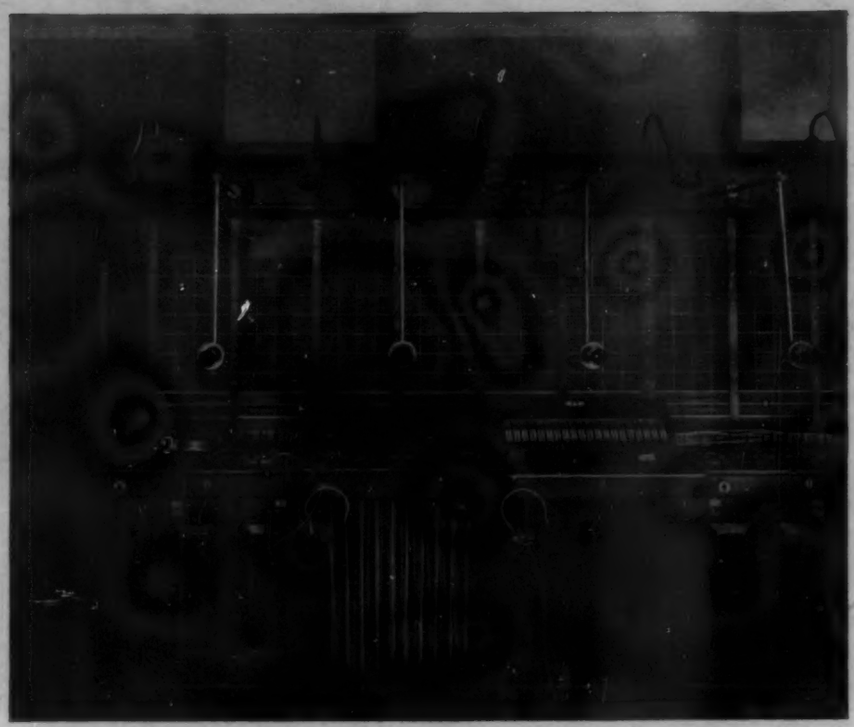


FIG. 13—FRONT OF PITTSBURG SECTIONS.

A limitation to the size of switchboards has heretofore necessitated a greater subdivision of offices in very large cities, than any of the considerations so far pointed out would warrant.

FIG. 15—REAR OF ST. LOUIS SWITCHBOARD.

Until recently it has been the policy of the Bell Telephone Company to establish no central offices having switchboard capacity for over 6,000 lines. This limit was maintained because of the fact that it has not been practicable to build multiple switchboards having a larger capacity than that. This limit in the capacity of the board has been due entirely to mechanical, rather than electrical conditions, and on account of it, it has been impracticable to build such exchanges as those of New York and Chicago, with single office, if other conditions had warranted it.

There has recently developed, however, a strong tendency on the part of the Bell and the Independent companies to build central offices with á much larger equipment than 6,000. The Cuyahoga Telephone Company of Cleveland, is now equipped with a multiple board having a capacity of nine thousand six hundred (9,600) lines installed, and with an ultimate capacity of about twenty thousand (20,000). The board at Paris, France, equipped by the Western Electric Company, has a present capacity of something like nine thousand three hundred (9,300) lines, and the Kinloch Telephone Company of St. Louis, Mo., has a present equipment of eight thousand eight hundred (8,800) lines. I am informed that a number of exchanges operated by the Bell Company are now being planned or built, having a capacity of nine thousand (9,000) lines and upward.

I believe fully that the future systems in large cities will be operated with fewer and fewer central offices and consequently with large switchboards. This belief is rendered tenable by the present tendency of operating companies, and also recent improvements in switchboards by which the mechanical limitation of six thousand (6,000) lines is removed, and by which as many as twenty-five thousand (25,000) lines can be handled in a single straight multiple switchboard, and even as great a number as one hundred thousand (100,000) lines by the use of systems now shown to be practicable for a smaller number.

The fundamental object of the multiple switchboard is to place within reach of every operator a line terminal or spring jack, as it is called, for every subscriber's line entering the exchange. As is well known, the switchboard is divided into sections, each section being of such size as to allow an operator, without undue exertion, to reach over its entire surface. On each section are placed a certain number of line signals, by which the subscriber is enabled to attract the attention of the operator and a corresponding number of line jacks, by means of which the operator may make the initial connection with that line in response to such signals. These jacks, which are associated with the line signals, are termed answering jacks. In addition to the line signals and answering jacks are provided what are termed multiple jacks, there being one of these on each section for every line in the exchange. To express this in a little different way, the various lines entering the central office are divided up into suitable groups, these groups terminating in line signals and answering jacks at the various sections of the multiple switchboard. In addition to this, all the lines entering an exchange are carried to every section of an exchange, each line terminating in every section in a multiple jack. An operator seated at any section, in response to a display of one of her line signals, inserts one plug of a pair into the corresponding jack, and, having ascertained the number of the subscriber desired, inserts a corresponding plug of the pair into the multiple jack of the subscriber called for. As every subscriber's line has a multiple jack at every section of the switchboard, any operator is able to complete by herself any connection called for at her board.

The size of the section is limited by the reach of the operator, and it is this fact that places a mechanical limit to the size of an ordinary multiple switchboard. It has been found impracticable in most cases to place the jacks closer than on half-inch centers, and under these conditions

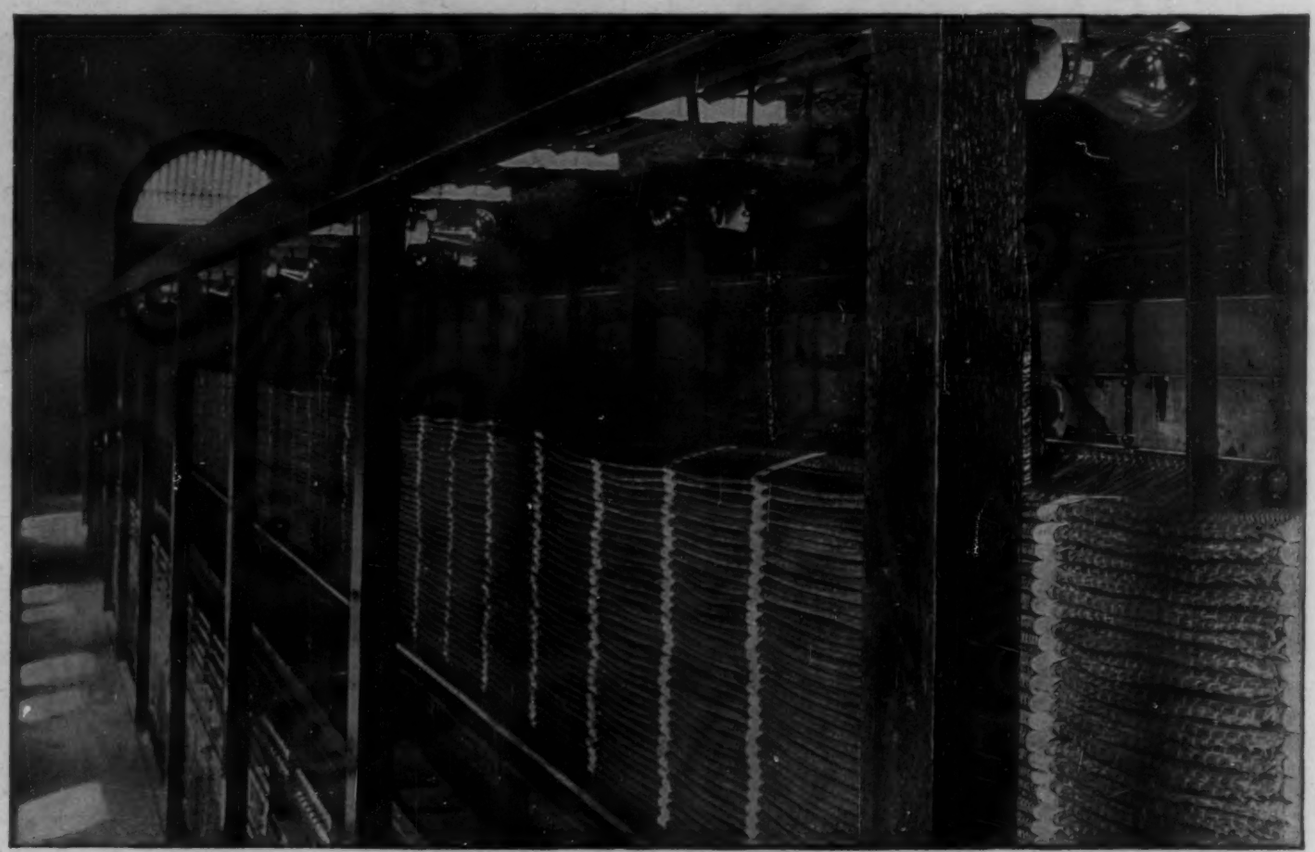


FIG. 16—REAR OF PITTSBURG MULTIPLE.

no more than six thousand (6,000) of the multiple jacks could be placed, in addition to the other apparatus, within the space afforded by one section.

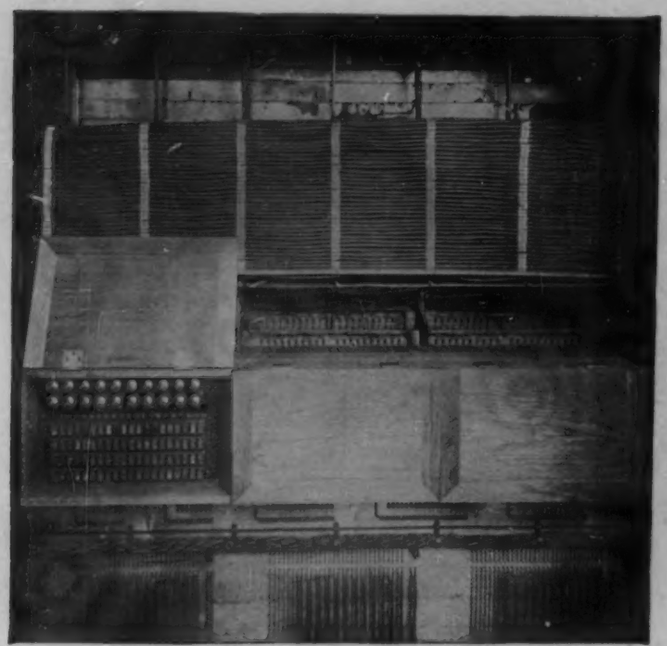


FIG. 17—REAR OF SINGLE PITTSBURG SECTION.

Two distinct methods have been followed with the intent of removing this limit. Each has been productive of excellent results; each has been used separately, but up to

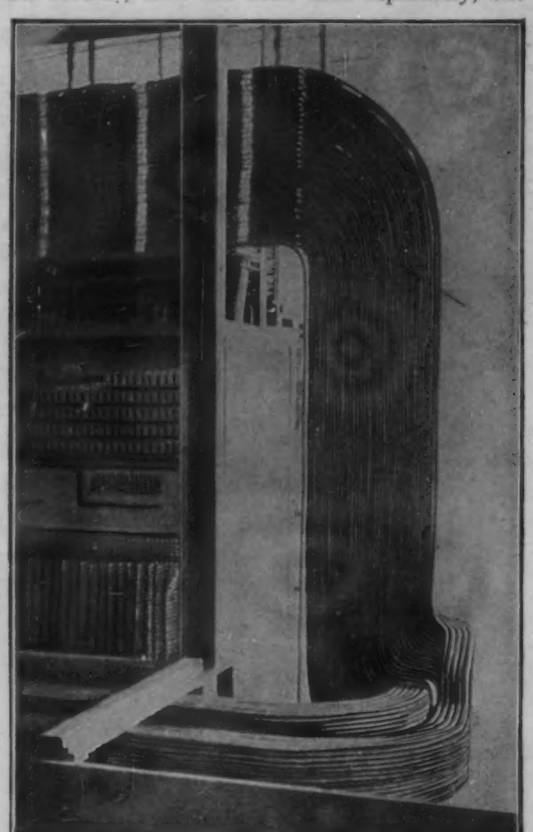


FIG. 18—MULTIPLE TURNING SECTION AT PITTSBURG.

the present time they have not both been incorporated into the same installation. The first of these methods is an obvious one and contemplates the reduction in the size of the spring jacks with a view to getting more of them within the reach of the operator. The mechanical difficulties in this line have been great, owing to the fact that the circuits of the switchboard were so complicated as to require three, four,

FIG. 19—PITTSBURG POWER PLANT.

and sometimes even five, contacts to each spring jack. The Western Electric Company in the Paris board succeeded in reducing the dimensions of the jack to three-eights of an inch (3/8 in.) centers, both horizontally and vertically, and

FIG. 20—PITTSBURG STORAGE BATTERIES.

thus rendered practicable the installation of a switchboard having a capacity for considerably over nine thousand (9,000) lines. I believe that there are other boards which have been installed with success having this size of jack,

and that others are at present in course of construction for large cities in this country. This jack had three contacts, and, I believe, is the smallest that has ever been put into extensive use.

Quite recently the company with which I am connected has perfected a system of circuits for a multiple switchboard so simplified that only two contact points are required for each jack; that is, merely a tip spring and sleeve, these two contacts always standing open and never engaging each other. By the use of this two-wire system, it is perfectly practicable to build the jacks on ¼-inch centers, horizontally and vertically, and thus place within the reach of a single operator no fewer than 25,000 lines.

The second method of increasing the possible size of multiple switchboards was devised by Mr. M. G. Kellogg, and is now working in two large exchanges in this country. In this system, which is known as the divided multiple system, the switchboard and lines are divided each into four divisions. The switchboard consists of four multiple boards, all in the same office, and to these is connected one of the groups of lines, in the same manner as if they were in separate exchanges. With this arrangement, if no further provisions were made, it would be possible for any subscriber in one division to obtain a connection with any other subscriber in his own division, but not with anyone in any of the other three divisions. In order to enable any subscriber in, say, the A division, to obtain a connection with a subscriber in the B, C or D division, means are provided, not for trunking between the divisions, but for enabling the calling subscriber to signal directly to one of the operators in the division in which the line of the called-for subscriber belongs. This necessitates the use of four line signals and four answering jacks for each line, one of each in each division, and of means whereby the subscriber may display any one of the signals to the exclusion of the others. Instead of trunking between exchanges, therefore, the subscriber sends his call directly into the division of switchboards to which the desired subscriber belongs.

By the use of this divided multiple switchboard it is seen that the ultimate capacity of any exchange is increased approximately fourfold; not quite this, however, because the extra line signals and answering jacks take up a portion of the room which would otherwise be available for the multiple jacks.

The significance of what I have said concerning the two methods of increasing the size of multiple switchboard will now be apparent. If the four division exchange were installed on ¼-inch centers, the capacity of such an exchange would be something over 90,000 lines operating without giving the operator as great a reach as they have at present in some multiple switchboards, and between the subscribers of this mammoth exchange there would be no trunking whatever.

FIG. 21—PITTSBURG REPEATING COIL RACK.

You may say that the divided multiple system introduces complications in the circuits, which is true! You may also say that operators will find difficulty in handling the jacks on ¼-inch centers, which may or may not be true! But with the demand for telephone service growing with an ever increasing rate as at present, who will say that the 100,000-line switchboard will not be required in the near future, and who at present can conceive of any other way of handling it?

During the past five years a complete revolution has been worked in the circuits and apparatus of telephone exchanges, due to the introduction of the systems known under such names as "common battery," "central battery" and "central energy." These systems, when properly equipped, have proven vastly superior from both an economic and operating standpoint to the old magneto systems, wherein local batteries were used for talking and magneto gen-

erators for making the calls. The local primary battery at the subscribers' station has been superseded by a large storage battery at the central office, which also takes the place of the old magneto generator. The mechanical signal or drop has given place to the lamp signal. By these innovations the apparatus at the subscribers' station has been rendered simpler and more compact, that at the central office more reliable, and the operation of the entire system

FIG. 22—LINE CONSTRUCTION, OLD ST. LOUIS EXCHANGE.

has been rendered automatic as far as the subscriber is concerned, and as much so as desirable as far as the operator is concerned. Such a system employs batteries at the central office for furnishing all current, for signaling by the subscriber and for the operation of the talking apparatus. These batteries are invariably secondary, rather than primary, for large exchanges, and operate almost universally at the voltage given by ten cells in series, *i. e.*, 20 to 24 volts, according to state of charge.

For charging these batteries and for furnishing current for ringing the subscribers' bells complete power plants

FIG. 23—CABLE VAULT, ST. LOUIS EXCHANGE.

are required, these consisting of suitable generating units, driven either electrically or mechanically, together with suitable controlling apparatus. Most companies depend upon electrical power, the charging and ringing machines being motor generators running directly from city mains.

It may be imagined that the failure of any source of energy in a large telephone system is a matter of most serious moment. The cutting off of one branch of the current supply would cause consternation in the entire business organization of a community. In order to prevent any such breakdown, all portions of the power plant are made in duplicate, and where it is possible duplicate primary sources of power are also made available. Frequently the large telephone companies employ their own steam generating plant, which they use constantly, with the current from city mains as a reserve supply.

The determination of the size of the storage batteries is the primary problem in the engineering work in connec-

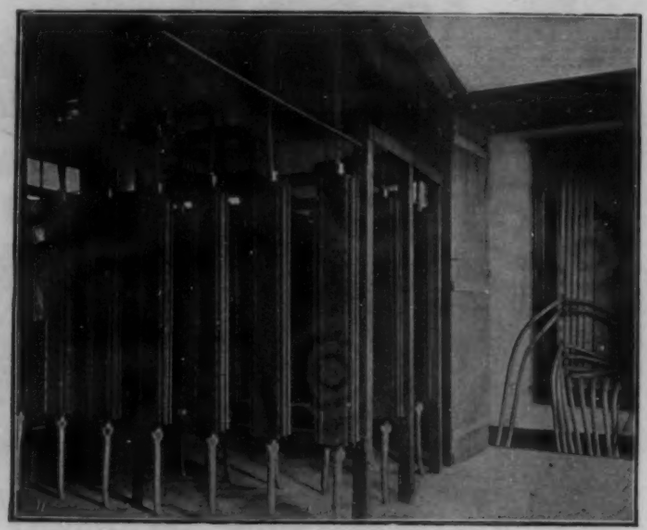


FIG. 24—CABLE HEADS.

tion with the telephone power plant, as, having once determined it, the size of the charging machines and the details of the other apparatus are readily ascertained. We know in a given city approximately the number of subscribers to be provided for in the present installation, and we make a guess at what the future number will be. Past experiences

FIG. 25—OLD ST. LOUIS DISTRIBUTING BOARD.

have proven that these guesses are almost always too small, for the growth of telephone service in the United States has far exceeded expectations. We also know by statistics from other cities approximately the number of calls each subscriber will make per day. This figure ranges from about eight calls per day in smaller and less active cities to something like thirty calls per day in our largest business centers. Experience has also taught us that the average length of time from the time a subscriber takes his telephone off his hook in making the call to the time the connection is

completed with the subscriber called for will vary not far from six seconds, if the service is prompt, and that the average length of conversation is somewhat less than two minutes. Knowing these figures and the average length, and therefore the average resistance of the various subscribers' lines, and of the connecting apparatus, the number of ampere hours required for the subscribers' circuits is readily determined. To this must be added the number of ampere hours required for the operators' transmitter circuits, the supervisory lamp circuits, and any other circuits that may exist. The whole may be reduced to a certain number of hundredths of ampere hours per connection, a most convenient unit.

Knowing the total number of ampere hours required of the storage battery in a day, a size of battery should be selected having that capacity in ampere hours, and also one having a discharge rate in amperes equal to one-sixth of the total ampere hours required. Experience has shown that the maximum discharge rate is equal to about one-sixth of the ampere hours required per day.

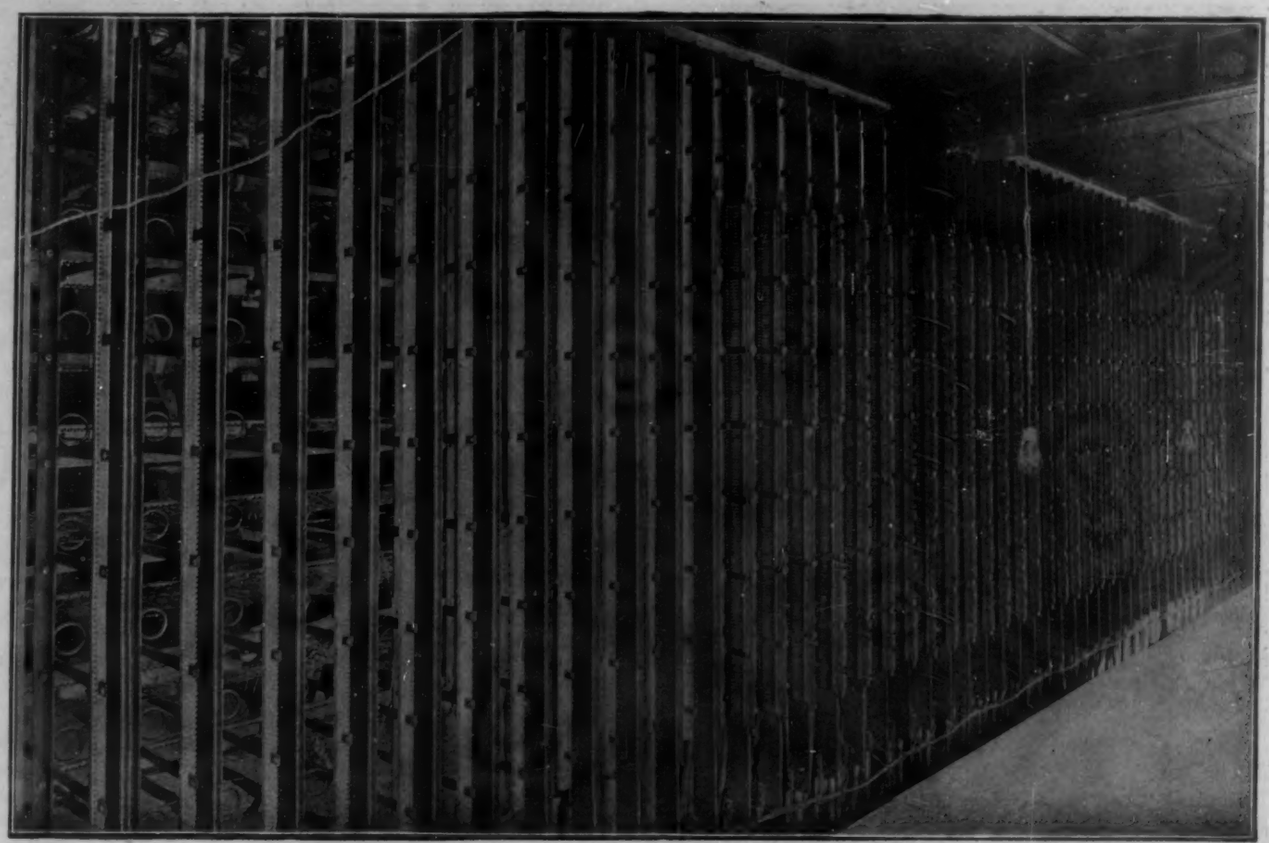


FIG. 26—NEW ST. LOUIS DISTRIBUTING BOARD.

The circuits of a telephone exchange are of such a complex nature as to defy adequate explanation in the short time available.

In the modern common battery exchange the operation is such that when a subscriber removes his receiver from the hook, a lamp will be automatically lighted in front of the operator at the central office, who handles the calls of the group of subscribers to which this particular subscriber belongs. The operator, in response to this signal, makes connection with the subscriber's line by inserting a plug into the spring jack of that line, and, after having ascertained his wants, completes the connection with the subscriber called for by means of a second plug attached to the first. As soon as a connection is thus made with a subscriber's line, the line lamp normally in control of the subscriber is disassociated from the line, but another lamp associated with the plug is placed under the control of the subscriber, this lamp being known as a supervisory lamp.

In Fig. 2 is shown a complete line circuit in diagram, including the apparatus at the subscriber's station, which is shown at the left, and the apparatus at the central office, which is shown at the right. The apparatus at the subscriber's station consists of an induction coil, a receiver, a granular carbon transmitter, a two microfarad condenser, a 1,000-ohm bell and an automatic hook-switch mounted in a suitable manner. It will be noticed from the diagram that the circuit between the two sides of the line is held open to direct currents by the condenser, and to all currents by the hook-switch contact, while the receiver is on the hook. This leaves the bell in operative relation to the line, for the purpose of receiving calls; the path of the ringing current, which current is, of course, alternating, being through one side of the line, through the bell and condenser to the other side of the line. When the receiver is removed from its hook, the circuit between the two sides of the line is closed, allowing the passage of direct current through the secondary of the induction coil and the transmitter in series. At the same time another circuit containing the transmitter, the receiver, the primary of the induction coil and the condenser is closed. The object of this latter circuit, which is local to the subscriber's station, will be pointed out later.

At the central office, in addition to the answering jack and the multiple jacks, there are two relays, one termed the line relay, which is normally in circuit across the line in series with the 24-volt storage battery common to all lines, and the other termed the cut-off relay, which is in an auxiliary circuit, and is adapted to open the circuit through the line relay and the battery as soon as a plug is inserted into any jack belonging to its line. Under normal conditions, both relays remain unoperated and the conditions are as shown. As soon, however, as the subscriber removes

his receiver from its hook, the circuit between the two sides of the line is made complete at the subscriber's station and the current at the central office energizes the relay and closes the circuit containing the line lamp and the battery. This lamp is located in immediate proximity to the answering jack, and the operator, seeing it illuminated, inserts a plug into the answering jack in response to the call. This plug is one of many pairs within the reach of the operator and has three contacts, two of which, the tip and sleeve, are adapted to engage the two springs of the answering jack, and thus complete the talking circuit. The third is adapted to engage the ring contact of the jack, and, being in connection with the live side of the battery, causes a current to pass fom this side of the battery through the ring contact of the jack and the coil of the cut-off relay back to the other side of the battery. The energization of the cut-off relay serves to open the circuit of the line relay, as already described, and this, when operated, extinguishes the lamp.

One of the cord circuits is now shown in Fig. 3. In this the answering and calling plugs are shown at the extreme left and right hand portions, respectively, each having, as beforesaid, three contacts, two of which, the tip and sleeve, are connected by wires shown in heavy lines, which form part of the talking circuit, and the third of which is connected through the supervisory signaling apparatus to the live side of the battery, as shown. The tip and sleeve sides of the answering plug are connected together through the two halves of one side of a repeating coil, between which is connected the common battery. In the same manner the tip and sleeve strands of the calling plug are connected by the two halves of the other winding of the repeating coil between which is connected to the same battery.

This repeating coil, and there is one of them for each pair of cords and plugs, has four windings, each having approximately 3,300 turns, all of these windings being on the same magnetic core. It is evident that these connections allow direct current from the storage battery to pass out over the metallic circuits of the two connected lines to energize the transmitters. A fluctuation in the current flowing in either line will, however, by induction between the windings of the repeating coil, cause a corresponding fluctuation in the current of the other line. In this way conversation between two connected lines is made possible, it being by induction rather than conduction.

In the sleeve strand of the cord of each plug is connected a supervisory relay, which is energized, as is readily seen, only while current is flowing over the line to which the corresponding plug is connected, *i. e.*, while the receiver of that line is off its hook. These relays control the circuit of supervisory lamps, by the illumination or darkness of which the operator is enabled to ascertain the condition of the connected lines. On the right of this figure is shown the ringing and listening keys. The former is a device for switching the alternating current generator into the circuit of the calling plug and its connected line; the latter connects the operator's head telephone, which is shown in the center of the diagram, across the two sides of the cord, in order to enable the operator to communicate with either subscriber.

FIG. 27—NEW ST. LOUIS DISTRIBUTING BOARD.

The operation of this circuit and apparatus can best be understood by referring to Fig. 4, which shows two subscribers' lines equipped as already described, connected by a cord circuit at the central office. Consider the line at the left to be that of the calling subscriber and that at the right the called. In the first place, the removing of the calling subscriber's receiver from its hook illuminates the line lamp, which remains lighted until the operator answers by the insertion of the answering plug into the answering jack. The operator, before inserting the calling plug into the jack of the called subscriber, must ascertain whether or not the line of that subscriber is already busy. This is automatically accomplished, for upon the touching of the

tip of the calling plug to the ring contact of the multiple jack, she will get a click in her head telephone if the line is busy, and silence if it is free. If the line is free, she inserts the plug to its full extent, and presses her ringing key, which rings the subscriber's bell. As soon as the calling plug is inserted the supervisory lamp, shown at the right-hand lower portion of the figure, will be illuminated, because its circuit will be completed from ground through

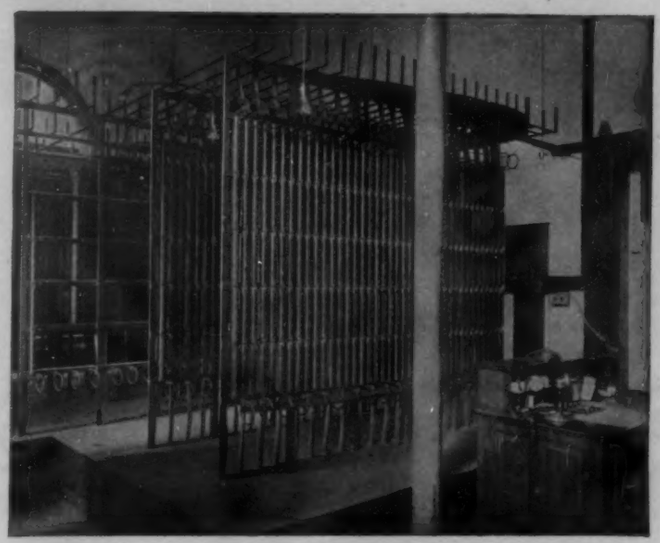


FIG. 28—KELLOGG DISTRIBUTING BOARD.

the battery, through the 90-ohm resistance coil and the lamp thence through the third strand of the cord, the test ring contact of the jack, and to ground through the cut-off relay. This current will not only illuminate the lamp, but will operate the cut-off relay of the line called for as well. As soon as the subscriber of this line responds, he will close the circuit between the two sides of his line and thus allow current to pass over the line to operate the transmitter. This current will pass through the supervisory relay, which will then be operated to close the low-resistance shunt about the lamp, and thus extinguish it. Both lamps are now out, and the operator pays no further attention to the connection until she sees one or both of the supervisory lamps again lighted. The corresponding lamp will be lighted when one or both of the subscribers hang up their receivers, which act will, by opening the circuit of the line, cause the corresponding supervisory relay to let go of its armature and thus remove the shunt about its lamp. When both lamps are thus lighted, the operator knows that the connection is no longer desired, and without further inquiry pulls down the plugs.

It is evident that any fluctuation in the resistance of the current of a transmitter at one subscriber's station will cause a corresponding fluctuation of the current flowing in the line, and this fluctuation will pass through the two windings forming one side of the repeating coil, which will act inductively on the two windings forming the other side of the repeating coil and produce a corresponding fluctuation in the other line. This latter fluctuation will pass through the secondary winding of the induction coil and the transmitter at the subscriber's station, and induce a corresponding fluctuation in the local circuit containing the receiver and the condenser.

One of the functions of this local circuit, which has already been referred to, is that of putting the receiver in inductive relation to the line without subjecting it to the passage of direct current through it, which circumstance might tend, if the receiver were connected up the wrong way, to demagnetize its magnets. This local circuit is, however, designed to accomplish still another result, this being the formation of a comparatively short path, through which the fluctuations set up by the transmitter may more readily pass; in other words, it is supposed to act as the local circuit of a sort of a booster to the outgoing telephone currents. The fluctuation in current caused by the transmitter pass through the condenser and primary winding of the induction coil, and thus induce on the secondary, which is in the line, fluctuations which tend to increase the fluctuations directly produced in the line by the transmitter.

So far, only such means have been described as would admit of the connecting of two subscribers whose lines terminate in the same exchange. Where several offices are used in the same system, the connections between subscribers in different offices are, as has already been pointed out, made by trunk lines extending between the offices. These trunk lines are spoken of as outgoing or incoming, according to which end of them is referred to. Thus an outgoing trunk line at one office would be an incoming trunk line at another. The distinction is obvious. The outgoing trunk lines usually terminate in jacks, in the regular sections of the multiple switchboard, while the incoming trunk lines usually terminate in plugs and cords and special apparatus, arranged at special incoming trunk sections, which sections are provided with multiple jacks in the same manner as the regular sections.

In Fig. 5 I have shown the circuits of a trunk line. The outgoing end of it at one office being shown at the left of the dotted line, while the incoming end, with its accompanying apparatus, is shown at the right. This circuit is somewhat complicated and will be better understood in connection with Figs. 6 and 7, which show a subscriber in one exchange connected through the local cord circuit at that exchange, and a trunk line with a subscriber at another exchange. Assuming that the subscriber at the left has sent in a call, the operator at one of the regular sections of the switchboard will answer it in the ordinary way by inserting a plug into the answering jack, and, having learned that

FIG. 29—HOOK SWITCH (1).

the connection desired is for a subscriber in another exchange, she presses her order wire key and communicates over the order wire with the incoming trunk operator at one of the incoming trunk sections of the branch exchange. The incoming trunk operator repeats the order and gives the number of an unused trunk line to the operator at the first exchange. The incoming trunk operator at the second exchange then tests the line in the ordinary way with the trunk line plug, and if it is found free, she completes the connection by inserting the plug in the multiple jack of that line. As soon as this operator completes the connection,

she sets the automatic ringing key, shown just to the left of her plug, which locks in the ringing position, because its controlling relay is not operated. The ringing generator is provided with an interrupter, each revolution of which switches the ringing current on to the line for one second and the 24-volt battery on to the line for five seconds. Thus the subscriber's bell rings for one second of every six until

FIG. 30—HOOK SWITCH (2).

he removes his receiver from its hook. When he does this, the current from the 24-volt battery, or from the ringing generator, whichever happens to be in circuit, passes through the primary magnet of the ringing key, and trips the latter into its normal position. By this means the bell of the subscriber is rung at intervals until he responds without any further attention on the part of the operator.

The insertion of the trunk plug into the jack of the called subscriber's line allows the current to flow from the battery through the test relay and disconnect lamp, shown at the extreme lower right-hand portion of the figure, and thence through the cut-off relay to ground. This does not light the disconnect lamp, because that lamp is already shunted by the armature of another relay contained directly in the trunk line circuit, this latter relay having been operated by the insertion of the plug into the trunk line jack at the other exchange. As soon as the ringing key is tripped the current from the battery at the incoming end of the trunk line flows through the metallic circuit of the subscriber's line to furnish current for talking. This operates the supervisory relay in the incoming cord circuit, and puts a ground on the sleeve side of the cord circuit at the first office,

FIG. 32—CUT-OFF RELAY.

thereby operating the calling supervisory relay at that office, and this shunts the corresponding supervisory lamp and extinguishes it, thus showing to the regular operator at the first office that the subscriber has responded. As soon as the subscriber called for hangs up his receiver, the supervisory relay at the incoming trunk section lets go of its armature and removes the ground from the sleeve side of the trunk line. This causes the calling supervisory relay at the first office to let go of its armature and remove the shunt from around the corresponding lamp. When both lamps of the regular pair of cords at the first office are lighted, the operator at that office pulls down the connection. By thus removing the calling plug from the trunk jack, current ceases to flow in the trunk line relay at the second office, which removes the shunt from the disconnect lamp at that office and allows it to be lighted for the first time. This is a signal for the incoming trunk operator to disconnect.

It will be seen from the above circuits that when two subscribers are connected over a trunk line, they are under the control of the originating operator. The disconnect signals from both subscribers go direct to this operator, and it is not until she has pulled down this connection that the disconnect signal is given to the operator at the other exchange. The latter operator has no means of listening in on the circuit.

An interesting feature about such trunking systems is the means by which the incoming trunk operator at the second office informs the calling subscriber and the regular operator that line called for is busy. When she finds on testing that a line is busy, she inserts the trunk line plug into the "busy back" jack, which jack has connected in its circuit a machine giving an interrupted current, which gives a peculiar, familiar, and, to most subscribers, an extremely disagreeable sound. The sound is

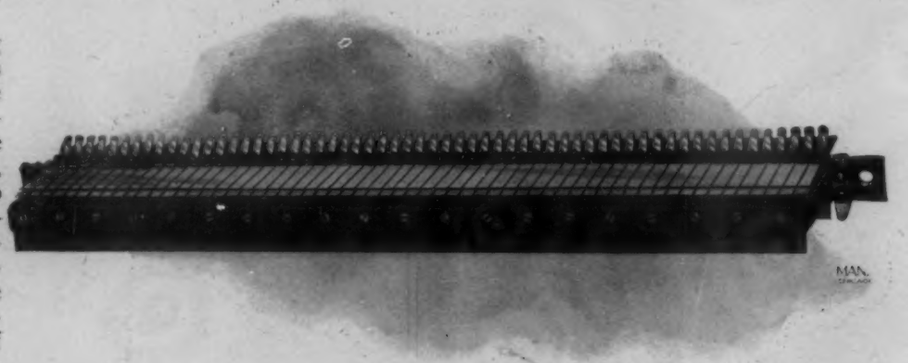


FIG. 31—STRIP OF LINE RELAYS.

heard by both operator and subscriber at the first office, and the disconnection is made.

* * * * *

There is probably no method of determining the relative activity of any city at different times of the day or on different days, so well as by watching the telephone exchange in that city in operation. For keeping track of their business and being able to handle it to the greatest advantage, telephone companies usually make at frequent intervals what they term "peg counts." These show the total number of calls received and connections made during each of the twenty-four hours of the day. These results if plotted in the form of a curve, in which the abscissæ represent time and the ordinates represent total number of calls per hour, show graphically and in a striking way the amount of telephone business being transacted at any given hour. The curves (Fig. 8) shows what I believe has never been shown before—that is, peg counts, taken the same day, of two opposition exchanges in the same city. These exchanges have about the same number of subscribers, not far from 6,000. The dotted curve represents the telephone activity in the Bell exchange, while the solid curve represents that of the Independent exchange. The rates of the Bell exchange are considerably higher than those of the Independent, and from this fact we are enabled to draw several conclusions from the form of the two curves.

It will be noticed that from twelve at midnight until six o'clock both curves are very low, and gradually fall until three o'clock, after which they slowly rise until six. This

shows conclusively that the hour of 3 a. m. is that of least business activity, except, perhaps, in those lines, such as burglary and other allied industries which seldom require the use of telephone service. From the hour of 6 a. m. each of the curves rise rapidly, corresponding to the awakening of the city, reaching a maximum for the day in the neighborhood of ten o'clock a. m. They then fall off to a minimum, corresponding to the lunch hour, between twelve and one, and again rise to a second maximum between the hours of four and five in the afternoon, after which they rapidly fall during the evening hours. The fact that the Independent exchange has cheaper telephones than the other will, perhaps, account for the fact that its subscribers begin work a little earlier in the morning, reach their maximum activity at a little earlier hour, take a little shorter time for lunch, go home a little later in the evening and work a little more all night, all of which facts are indicated by these two curves.

In Fig. 9 I show two curves representing telephone activity of the same city on two different dates. It will be noticed that the dotted curve, which represents a Monday, shows a greater number of calls than the solid curve, which was taken on a Wednesday. It is usually true that Monday is about the busiest day in the week in telephonic exchanges. It would be interesting to trace the significance of the different humps or characteristics of these curves, but it will be noticed that whatever hump is on one is present, or at least suggested, on the other. The pronounced hump on the dotted curve at the extreme right is undoubtedly due to the theater business, between seven and eight in the evening. Probably the reason why this was more pronounced on one curve than on the other was that there was a special attraction or special set of attractions, in the entertainment line, on the particular day on which the curve was taken. Such curves as these have been said by someone to represent the pulse of a city, and I think that the longer one thinks about it the more apt this term appears. Every city has a heart in its telephone exchange, and this heart is throbbing with as great a regularity as that of any living creature.

I will now, in conclusion, show a number of pictures of telephone exchanges and apparatus, which I think will be of general interest, and which, perhaps, will make some of the statements which I have made more clear to those not well posted in telephony. My first view in this series (Fig. 10) is that of the interior of the exchange installed by the Western Electric Company, at Paris, France. This board is next to the largest in the world, it having a capacity of something like 9,300 lines. The next (Fig. 10) is that of the switchboard at the main office of the Bell Company of Missouri, at St. Louis. This board consists of nineteen sections with three operators' positions at each section. Its total length over all is about 115 feet, and it is wired at present for 4,000 subscribers, with an ultimate capacity for 5,600.

FIG. 33—STRIP OF LINE AND CUT-OFF RELAYS (BACK).

FIG. 34—STRIP OF LINE AND CUT-OFF RELAYS (FRONT).

The next view (Fig. 11) is that of the multiple board installed for the Pittsburg & Allegheny Telephone Company of Pittsburg, Pa., by the Kellogg Switchboard & Supply Company. This board is now wired for 4,080 lines and has an ultimate capacity of 6,000. It forms the main office of the Pittsburg & Allegheny exchange, there being six branch offices located in the various parts of Pittsburg and Allegheny, all operating in conjunction with the exchange here

FIG. 35—STRIP OF DROPS.

shown. The total present equipment of these offices is about 7,000 lines.

Fig. 12 shows the front view of one of the sections of the great switchboard at Paris, shown in Fig. 9. In this board mechanical annunciators of the electrically self-restoring type were used, which can be seen at the extreme top of the section. Those signals are automatically restored when the operator inserts a plug into the answering jack, but this arrangement has a marked disadvantage over the more modern form of boards wherein the line signals are located in the immediate vicinity of the answering jacks. With the drops, as shown in this section, the operator had first to look to the top of the section, fix the number of the signal displayed in her mind, and then look down and pick out the corresponding answering jack, in which to insert the plug. In the later boards, where the line signal is next to the corresponding answering jack, she is saved this change of vision, and also this mental operation. She simply plugs into the jack next to the signal displayed without any regard to its number.

FIG. 36—STRIP OF LAMPS.

In Fig. 13 is shown a front view of several of the sections of the Pittsburg exchange, a complete view of which was just seen, and in Fig. 14 a closer view of one of the sections. Here the multiple jacks are plainly seen in the upper portion of the board, the answering jacks and line signals being shown below. One of the key shelves is raised, showing the wiring of the ringing and listening keys, and also the springs of these keys. Below this one of the front panels is removed showing some details of the wiring of the connecting rack of the section.

The next view (Fig. 15) is that of the rear of the St. Louis Switchboard. The cables leading to the multiple jacks are shown in the upper portion of this picture, and below them the cord racks, the supervisory relays and the running box containing the various line cables are clearly shown.

Fig. 16 is a similar view of the rear sections of the Pittsburg exchange, a good idea of the multiple cables being afforded.

Fig. 17 shows with greater detail the rear of one of the Pittsburg sections. The multiple cables are seen at the top and below these are the relay boxes, one of which is open, disclosing the supervisory relays at the top and the line relays of that particular position. In the lower portion of the picture is shown the connecting rack, to which all of the wiring of this particular section is led.

In Fig. 18 is shown the turning section of the multiple cables. This is at the end of the switchboard and shows where the multiple cables are turned downward into the running box, where they run along back of the sections, and are joined to their proper answering jacks and signaling circuits on the connecting rack of each section.

In Fig. 19 is shown what might be called the heart and lungs of a telephone exchange. This is the power plant of the Pittsburg and Allegheny exchange. On the right is seen the power switchboard, which is of marble, and is provided with voltmeters and ammeters, circuit breakers, and all switches necessary for handling the machines and batteries. In the center of the picture are shown the two ringing machines and on the right the charging machines for charging the storage batteries.

I will now show (Fig. 20) the storage batteries of this same exchange, these comprising ten cells each of chloride accumulator, each cell being of 800-ampere-hours capacity. The tanks are of wood, lined with lead, and the floor and walls are of tile laid in cement. At the upper left hand portion of the picture may be seen the heavy copper bus-bars forming the discharge leads of these batteries. These are of solid copper, 3 inches by one-half inch in thickness.

The next view (Fig. 21) shows the repeating coils of the Pittsburg and Allegheny system, there being one of these coils for each pair of cords in the entire exchange. These coils are iron clad and are inclosed, as shown, in a practically dustproof cabinet. It is through these coils that the current from the storage battery is led to the various cord circuits, whence it passes to the lines of connected subscribers to furnish talking current.

No single feature of telephone work has shown greater advancement than that of outside line construction. In place of the overhead wire, so common a few years ago, and still too common, the lines in systems are being placed under ground to a greater and greater extent. My next picture (Fig. 22) illustrates a piece of overhead construction, showing lines as they were about to enter the exchange of the old system at St. Louis, Mo. In marked contrast to this, the next (Fig. 23) is a picture which shows how the subscribers' lines now enter the exchange building in that same St. Louis system. This is a picture of an underground cable vault and shows with what care and system the cables coming in from the street are led into the cable shaft leading to the exchange room.

FIG. 37—STRIP OF JACKS.

The next view (Fig. 24) shows a common method of terminating the lines of telephone exchanges, or rather terminating the outside construction work. The line cables may be seen leading up from the lower part of the picture. These enter the cable heads, which are, in this case, cast-iron boxes hermetically sealed, and the various wires of the cables are distributed to insulated contact points on the inside of the boxes. These contact points extend to the outside of the boxes through insulated bushings, and from

thence the circuit is led through protecting devices, after which they are again arranged into cables which proceed from the top of the cable heads and are then led to the switchboard terminals.

This brings up the subject of distributing boards. A little thought will show that some means must be provided for distributing the various line wires which enter the exchange to their proper terminals on the switchboard, and to enable such changes to be made in this distribution as required. If such provision were not made and the line cables were run directly to the switchboard, the wires in one 100-pair cable being led, for instance, to the first position, and

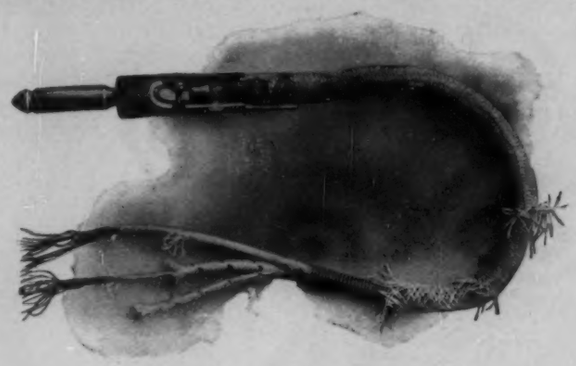


FIG. 38—CORD AND PLUG IN SECTION.

the wires in the second 100-pair cable to the second position, etc., it would be necessary at any time when a change in a subscriber's number was desired, to open the cable, take out the proper wire and fasten it to one of the other cables leading to the proper section of the board. The changing about of the various line wires from one part of the board to another is a very common occurrence, and to do it in the manner just suggested would be wholly impracticable. In order to provide means for systematically making such changes, recourse is had to what are called distributing boards or frames. These assume a great variety of forms, but the principle upon which they are designed is as follows: In one portion of the distributing board are placed clips suitably arranged, in which the wires of the line cables may terminate. On another portion of the distributing board is arranged another group of clips or connectors in which the separate wires of the switchboard cables may terminate. We thus have all connections from the lines, and also all connections from the switchboard wired in a permanent manner to the various connectors on the respective portions of the distributing board. The gap between the terminals of any pair of wires on the line side of the distributing board, and those of the corresponding pair leading from the switchboard is filled by means of bridle or jumper wires. The distributing board is so arranged that these jumper wires may be run from any pair of connectors on the line side to any pair on the switchboard side, and if the distributing board is a good one, these jumper wires are laid with perfect system and may be changed as often as desired.

In Fig. 25 is shown a distributing board which is happily a relic of the past, but which in its day was distinctly superior to others and may be said to have served its purpose well. This picture was taken from the inside of the distributing board which was in the form of a hollow square, one corner of which is shown. This accommodated about 4,000 lines entering the old Bell exchange at the corner of Fourth and Pine streets, in St. Louis. The line wires were practically all aerial and were brought to a large tower at the top of the exchange building; they were then led down in suitable cables, as shown in this picture, which cables were fanned out for attachment to the clips on the upper portion of the distributing board. In the same manner the switchboard cables were led up to the lower set of clips on the distributing board. Connection between any line wire and any switchboard wire was then completed by means of the jumper wires, as readily seen.

It is the object of modern distributing boards to do away with the confusion in these jumper wires and to lead them as far as possible in parallel directions in their courses from the line to the switchboard sides of the frames. My next view (Fig. 26) shows the switchboard side of the distributing board of the present main exchange of St. Louis, which exchange takes the place of the old exchange, the distributing board of which was just shown. The switchboard cables may be seen leading up from beneath. They are fanned out to the lightning arrester terminals shown on the right hand portion of the board, these terminals being omitted from the left hand portion, which latter portion is reserved for future growth. These arresters contain a device which will open the line and ground it if an extraneous current of sufficient intensity to be considered dangerous comes in over the line. Such currents are termed sneak currents, and would do great damage but for these little protectors. The protectors also include static arresters, by means of which a high potential current is caused to jump to ground rather than go on through the intricacies of the switchboard. The jumper wires are led from the terminals on this side of the distributing board through iron rings, some of which may be seen at the extreme left of the picture and to the line side of the distributing board, a view of which (Fig. 27) is now shown. The terminals on this side are arranged in horizontal rows, and the jumper wires coming from the line side, after passing through their respective rings, are led up or down as the case may be, to the particular horizontal row on which the desired terminal exists, and are then led along the corresponding horizontal shelf to the proper terminal. The cables leading in from the street are permanently connected to these horizontal rows of terminals and may be

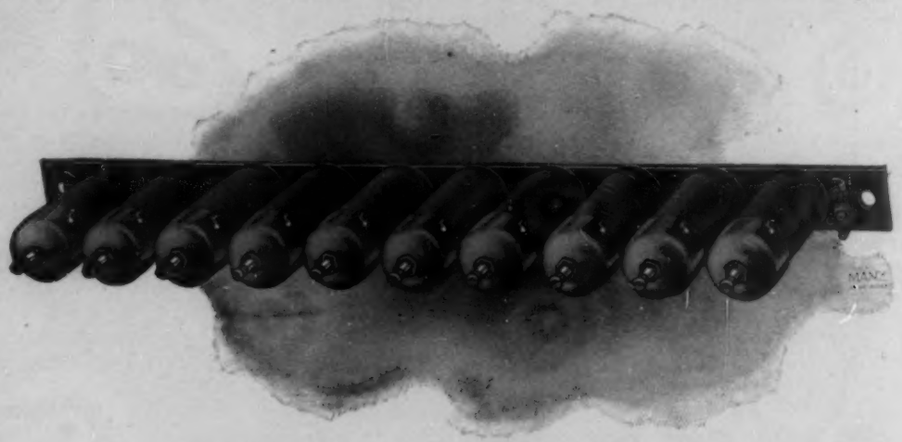


FIG. 39—STRIP OF SUPERVISORY RELAYS.

seen coming in at the bottom portion of the board through the trap door in the floor.

The next view (Fig. 28) shows a Kellogg distributing board, this particular one being that at the Pittsburg exchange already referred to. The peculiar feature of this board is that the line and switchboard terminals, instead of being arranged on opposite sides of the framework, as on the board just described, are arranged on alternate vertical strips, there being a strip of switchboard terminals and then a strip of line terminals, and so on. The arresters in this case are put on the cable heads, which may be seen in the

rear of the view. Jumper wires are led up or down from the respective line terminals through the large iron rings seen at the bottom and top of the board, and then horizontally to the proper strip of line terminals, and then up or down to the proper terminal on this. The cables from the cable heads in the rear are led up to the line strips from beneath, as clearly shown, while the cables leading to the switchboard may be seen in the iron running frame at the top of the picture.

I have had a few slides prepared representing in detail parts of the apparatus used in some of the latest Kellogg exchanges. I show here (Fig. 29) a subscriber's automatic switch-hook with the receiver upon it. The next picture (Fig. 30) shows the same hook with the receiver removed. It will be seen that the long lever serves to bend the central spring into engagement with the lower or upper set of springs according to whether the telephone is in use or not. This accomplishes the changes of circuit by which the operator is automatically called and by which she is later given the signal to disconnect, which changes are made, of course, entirely without the volition or knowledge of the subscriber.

Passing on to the central office, I will show (Fig. 31) a strip of line relays similar to the ones used in the Pittsburg exchange. These relays are mounted twenty per strip, as shown.

The next cut (Fig. 32) shows a single line cut-off relay. The magnet of this is inclosed in an iron shell which forms a portion of the magnetic circuit. The armature of this

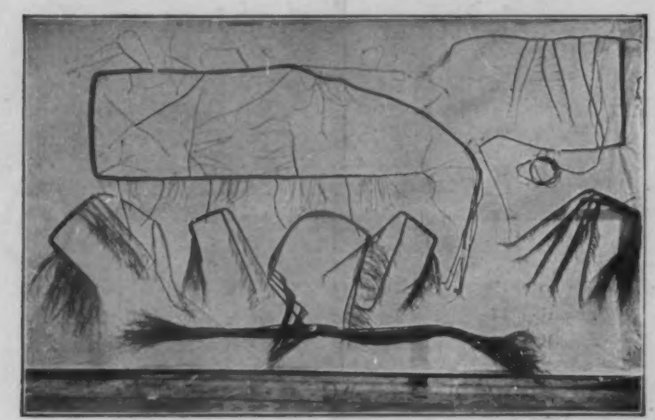


FIG. 40—CABLES FANNED OUT.

relay, when attracted, causes the two long springs to break contact with the lower springs, and to make contact with the two upper springs. I may say, in passing, that all contacts in the best relays of this description are made of platinum. These relays are about 1¼ inches in diameter and the shells are of soft iron, about ⅛ inch thick.

In the latest Kellogg exchanges the line and cut-off relays are mounted side by side on the same strip. The view (Fig. 33) shows such a strip containing twenty of each relays, the line relays being the smaller of the two. This strip represents a unit of twenty lines, which unit is carried throughout the entire scheme of wiring in the central office. The next illustration (Fig. 34) shows the opposite side of this relay strip, showing the connecting wires from the various terminals. These terminals pass through walls in the iron mounting strip and are readily accessible for soldering in the wires. In mounting the line and the cut-off relay in such close proximity, many of the wires which would otherwise have to be formed up in cables are reduced to the short, stiff bare wires clearly shown in this picture.

Coming now to the line signals themselves, in Fig. 35, I show a strip of drops, these being mounted on one-half-inch centers so as to correspond to the spacing of the jacks. These were used before the adoption of the line lamp signals by the Kellogg Company, a strip of which signal is shown in Fig. 36.

This strip is formed from a single piece of hard rubber about 10 inches long and one-half inch thick. The lamps, one of which is shown in the front of the view, are so arranged as to slide into their sockets between the jack springs in such manner as to make the proper circuit connections. In front of each lamp is a little lens, usually of opalescent glass, this lens being carried in a spun brass cap. The advantages of the line lamp signal over the old form of mechanical signal is obvious, the principal ones being the absolute freedom from complexity, cheapness, and the fact that they may be removed instantly if found defective and replaced by good ones. A defective line lamp may be taken out and another one substituted in less than one-half minute. Another beauty of the line lamp is that when it is out of order it may be thrown away, which is much easier than repairing a mechanical drop. These lamps usually operate at 20 or 24 volts, take about one-quarter ampere and give approximately one-third candle-power. The calculated life of these lamps, with their present degree of perfection and with the average rate of use, is about thirty years, but, of course, this figure remains to be verified by actual service, for unfortunately the telephone business is not yet old enough to prove the statement.

I now show (Fig. 37) what is by all odds the most important piece of apparatus in a telephone exchange—the spring jack. This is a strip of the two-point jack already referred to, and it will be seen that they are mounted twenty to a strip on spaces corresponding to those of the lamp jack. The same jack is used for both answering and multiple. This strip is built up of hard rubber, brass and German silver, the front being a solid piece of hard rubber, slightly over 10 inches long, and drilled for receiving the sleeve contacts. The rear of the strip is a piece of hard rubber milled to receive the line springs and the rearwardly projecting lugs from the sleeve contacts. This rear strip is reinforced by a heavy brass strip, into which the screws holding the line springs are threaded. In this particular strip the jacks are on one-half-inch centers, the strip being seven-sixteenths inch high. The spacing with this same construction is readily reduced to three-eighths inch. Where a smaller spacing than this is required, as in a board of extreme size, a somewhat different construction would be used.

I have spoken throughout the evening of cords and plugs, with the details of which some present may not be familiar. The next picture (Fig. 38) shows one of each, the plug being cut away to expose the method of attaching the cord, the cord having its various layers removed to better show its construction. This plug has two contact points instead of three, as described in connection with Western Electric or Bell system. It will be noticed that the two strands of the cord are composed of twisted tinsel, over which a wrapping of floss silk and a braid of cotton are placed. Thus insulated, the two conductors are bound together by a wrapping of cotton, after which they are inclosed in a spiral brass wire for protection. Over the spiral of wire are placed two layers of linen braiding throughout the entire length of the cord, and for about 10 inches back of the plug a third reinforcing layer is put on. These cords vary in length, according to the size of the multiple board, this length being anywhere from 36 inches up to nearly 100 inches.

The next view (Fig. 39) shows a strip of ten supervisory relays, these relays being the ones used in connection with the cord circuit for controlling the supervisory lamps. These are iron clad, being made in the same shell as is used for the cut-off relay. The armature, a disk of iron about 1¼ inches in diameter, is suspended in front of the poles of the electromagnet by a thin leaf spring. The working parts of the relay, including the armature and contact points, are inclosed in a brass cap, which cap locks on the shell with a bayonet joint.

The next and last view (Fig. 40) shows a few of the cables used in switchboard work, as they are formed up in

the factory. Some of these are made from standard 21 and 41 pair cables in long lengths, with their ends formed and laced to fit the particular portion of the switchboard for which they are required. Some of the other cables are formed by hand, exactly as shown, directly from the insulated wire, which is usually twisted in pairs. These cables, as you will see, remind one more of diagrams of nervous systems, sometimes seen in medical books, than anything else I can think of.

The design of telephone switchboards and apparatus is a matter requiring attention to almost infinite detail. Besides having a knowledge of the requirements of telephone service and a thorough appreciation of the engineering problems involved, the designer must have a peculiar faculty, which has been termed "telephone sense." Ability to distinguish between appartus and circuits that will work successfully in practice, from those that will work only in the laboratory, is not acquired by all; and the problems are so remote from those of other branches of electrical engineering, that it is seldom that precedent taken from other branches can be found.

Those who have the best interest of the telephone business at heart are now designing their apparatus and circuits on the basis that telephone systems in small villages must have as good transmission as those in the largest cities, with the idea in view that in the future the whole contingent will be one vast telephone exchange, the various large cities being the main offices, the long-distance lines, the trunk lines between them, and the villages the branch exchanges.

I regret that time, together with a lack of definite information, prevents me from treating of Dr. Pupin's recent invention, but this subject is one of such apparent importance that to devote less than a whole evening to it would be to do both the inventor and the audience an injustice.

TELEPHONES IN KANSAS.

A telephone directory of the independent exchanges and toll stations in Central Kansas has been issued, which reminds one of the fact that as late as 1895 there was not an independent company in Kansas and what few exchanges and toll stations there were at that time were operated by the Bell Telephone Company, and the prices were so exorbitant that a telephone was a luxury instead of the necessity as it is to-day.

After the expiration of the Bell patents, companies were organized and exchanges were built, and to-day there are in Kansas over 100 large exchanges with from 150 to 600 subscribers each, besides almost every town and village east of Great Bend is connected with the outside world by telephone toll stations. These exchanges and toll stations are operated by about 150 different companies, capitalized at from $5,000 to $15,000 each, and the companies combined control over 5,000 miles of wire, and have thousands of subscribers.

The farm line systems this year will be about the biggest part of the telephone construction. These systems are built by the independent companies where a sufficient number of subscribers can be secured to warrant the building of the line, and before long the Kansas farmer will have telephones and can call up the nearest elevator to ascertain the price of wheat and other products of the farm without being compelled to haul his truck to town only to find a disappointed market for his stock.

In a very short time the Pennsylvania Railroad will have a long distance telephone line extending from Philadelphia to Pittsburg. Already the company has a line completed from Harrisburg to Altoona and there are stretches of wires between important points on the Pittsburg division. There is at present a line from Philadelphia to Columbia, and it is proposed to extend it to Harrisburg. Thus a line will be established between Philadelphia and Altoona. Then work will be started on joining the western lines to the eastern in order to complete the big loop. In time every part of the big system will be in communication by telephone with the central offices. The line on the middle division has proven a great convenience.

WELL-KNOWN HEADS OF WELL-KNOWN HOUSES.

A BIOGRAPHICAL SKETCH OF JOSEPH A. WILLIAMS.

Mr. Joseph A. Williams, whose portrait is presented herewith, is President and General Manager of The Williams Electric Company, Cleveland, Ohio. Mr. Williams is one of the best known telephone manufacturers in the independent field.

He was born in Harris County, Georgia, December 22, 1870, and received his education in one of the Southern colleges. His principal studies were electrical and mechanical engineering. After completing his collegiate duties, he went to Cleveland and entered the employ of the Brush Electric Company and worked through all of the departments of their factory as a learner, and later entered the employ of the Cleveland Electrical Mfg. Co., who did a large variety of electrical manufacturing and construction work. After being at the head of their staff of electricians for two years, he left their employ to engage in business for himself. In the summer of 1894 he founded the Williams-Abbott Electric Company and in the spring of 1898 disposed of his interest in that company and founded his present business connection, The Williams Electric Company.

JOSEPH A. WILLIAMS.

Mr. Williams, besides having a complete theoretical education of electrical problems, has also a thorough practical training in the manufacture of electrical wares of all kinds, and especially of telephones. He is the inventor of many valuable improvements in telephony, which are now used in the independent telephone field.

He was among the first to begin the manufacture of telephones with which to compete with the Bell Company, and has a host of friends among exchange owners and managers.

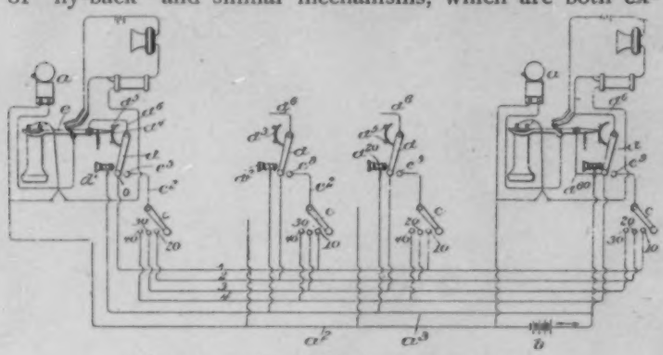
DIGEST OF TELEPHONE AND KINDRED PATENTS.

COMPOSED BY EDWARD E. CLEMENT.

MARCH 19.

670,022—N. H. Holland, Intercommunicating Telephone System.

This is an intercommunicating system in which it is immaterial whether the selective switch at any station is returned to the home point or not after a communication. Of course the motive for the invention is the avoidance of "fly-back" and similar mechanisms, which are both ex-



670,022—INTERCOMMUNICATING SYSTEM.

pensive and unreliable. It is noticeable that the patent is assigned to the Holtzer-Cabot Company, which has put out many "fly-back" switches.

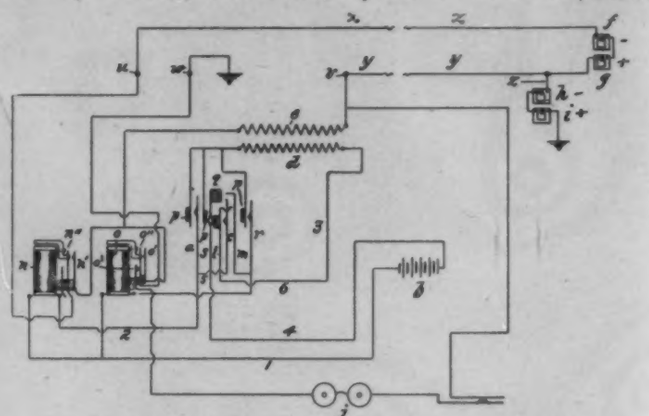
In the figure, stations 1, 2, 3 and 4 are shown, Nos. 1 and 4 with their circuits in full. Each station has its individual wire, 1, 2, 3 or 4, in the cable, and two battery wires, a^2 and a^3, are provided, the first having branches to all the bells, a a a a, and the second having similar branches to all the calling push buttons, d^2, d^{20}, etc.

In calling from station 1 to station 4, the operator sets the switch c on contact 40, and depresses button d'. This forces switch arm d over onto contact c^2, and connects the wire a^2 to wire c^2 and so to wire 40 and to station 4. Current then flows from battery b through the path indicated, and at station 40 through wire d^{20} to switch hook and bell a, thence back to wire a^2 and battery. When the hand is withdrawn from button d' the latter springs back from switch d, which remains on the contact point c^2, however, until the termination of the conversation. The switch is then restored by the hook e in the following manner: A curved spring d^4 is provided on the switch arm d, which rests against the pins d^5, and has a perforation d^4 opposite the normal position of the heel of the switchhook e. When the receiver is taken down the heel of the hook passes down over the spring and the latter snaps forward with the heel in the perforation d^4, so that when the receiver is hung up again the switch d is pulled back onto contact o.

670,408—T. W. Loaring, Signalling Apparatus for Telephone Stations.

This is a set of signal apparatus for a subscriber's station whereby impulses of opposite polarity may be sent at will to central to actuate polarized annunciators assumed to be located upon different sections of the switchboard. The system for which it is intended is that known as "divided multiple," each line having an annunciator on each of the division of the board, a multiple jack on every section of its own division, and one multiple jack only on every other division. This method of dividing multiple boards so as to save a large proportion of the multiple jacks has been known for years, Mr. Scribner and others having produced schemes for its employment, and some patents thereon having been taken out by Mr. Kellogg. In such schemes the commonest way of producing the current of varying polarity at the subscribers' stations has been by means of a generator with switching devices to alter its connection to line at will, these being usually manipulated by means of push buttons on the front of the generator box. In the present case a local battery is provided, and two small relays, with an induction coil, impulses of either polarity in the primary being produced by changing the direction of connection of the battery thereto, and secondary impulses being sent to line and central.

In the figure b is the local battery, n and o are relays with rocker armatures, d is the primary and e is the secondary of the induction coil, x-y are the line wires, and



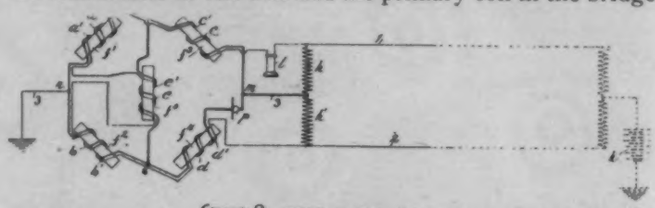
670,408—SIGNALING APPARATUS.

f, g, h, i are the polarized annunciators at the central office; a, c, m, r are springs lying under the pushes on the box front, one pair being adapted to send plus and minus current impulses through the metallic circuit and annunciators f and g; while the other pair change the connections so as to throw plus or minus impulses through the ground circuit to annunciators h and i. The relays n, o serve to connect the coil to line as required, the relay o also breaking the local bell circuit, which would otherwise short circuit the transmitting combination.

MARCH 26.

670,538—W. W. Dean, Subscribers Telephone Circuit.

This is a scheme of circuits for transmitter connection where the energy required is supplied from a central point over the subscriber's line wires used in parallel as one conductor. Such connections have been used before by Mr. Carty and others, Wheatstone bridges being employed with the transmitter in one arm and the primary coil in the bridge.



670,538—TELEPHONE CIRCUIT.

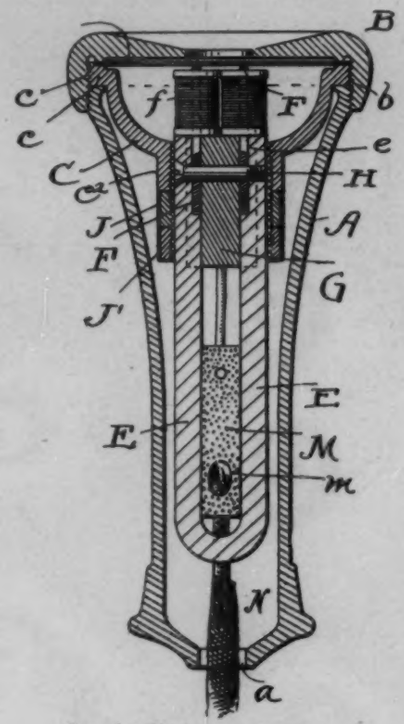
In the present case a primary winding is placed in each arm of the bridge, and one also in the bridge wire, the transmitter being included in one of the arms. The coils in the arms are connected in series, to produce a cumulative effect and to utilize the sum of all current changes produced by the variations in transmitter resistance. Such arrangements have heretofore proved less efficient than the simple bridge connection, but they have usually had a resistance couple in every arm, as well as a primary coil.

In the figure current flows from the central office battery k through line wires 1-2 in parallel to and through coils h h' and wire 3, and thence through the bridge arms, and the four coils, c-a, d-b, and by wire 3 to earth and back to central. Between points r-s the bridge wire also contains a coil e. Secondary coils c', a', e', b', d', are all connected in series with each other and the line wires 1-2.

670,564, C. H. North, Telephone Receiver.

This is a bipolar receiver having a cup C supporting the magnet structure through an adjustable connection and

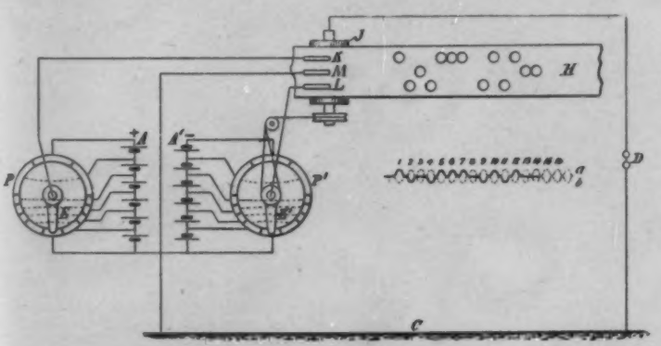
itself supporting the diaphragm D and threaded into the cap B. A perforated insulating block M receives the ends of the cord, which are passed through it in reversed directions before being carried to the terminals of the coils, thereby making a mechanical connection independent of the terminals and preventing accidental breakage of the connections.



670,564—TELEPHONE RECEIVER.

670,697, F. Bedell, System of Telegraphy.

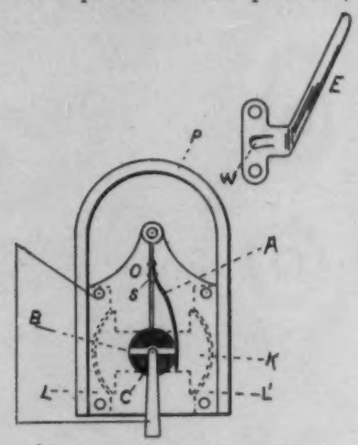
This is a system employing a plurality of sources of electromotive force, instead of a single constant source furnishing both positive and negative impulses, together with means to cut in and out the several sources in sequence, whereby a predetermined graduated rise and fall in the electromotive force on the line may be produced. Means are also provided for grounding or short-circuiting the line at moments of zero potential difference between the line and ground, whereby a discharge of the line may be effected



670,697—SYSTEM OF TELEGRAPHY.

without reactive disturbances. The system is applicable to land or marine cables or other lines, and is generally analogous to the systems of rapid transmission which have recently attracted general attention on account of the use of alternating currents.

In the figure A A' are two groups of cells, primary or secondary, arranged to supply current of one or the other polarity to the line B, through the medium of rotating arms E and E', which in their rotation cut in the elements of each group in increasing, and then cut them out in decreasing, succession. For this purpose it will be noticed that the opposite segments of the contact rings P and P' are connected together in pairs. The rate of increase in the electromotive force or its decrease is regulated by the rate of motion of the arms, or as shown by the varying length of the segments. The line terminates in a metal cylinder J, over which a paper tape with perforations H is drawn at such a rate that the perforations come under brushes K M L at points of zero potential, the brush K



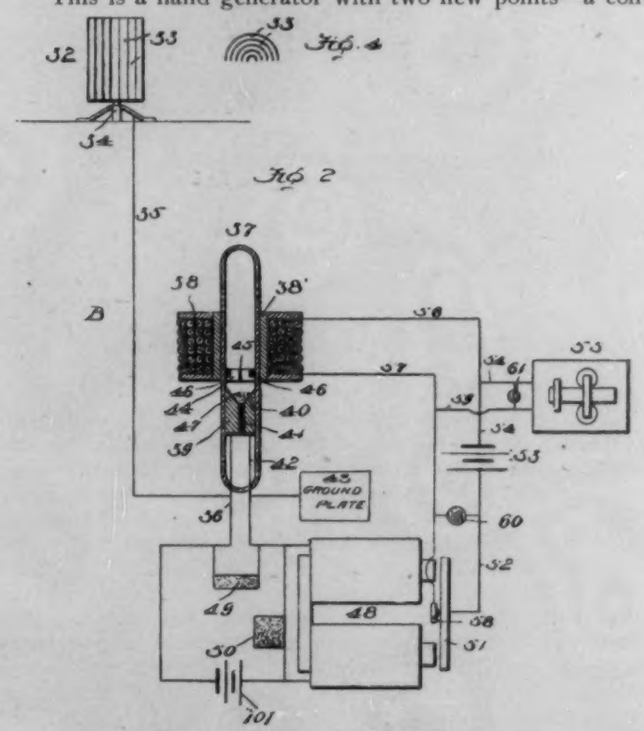
671,311—TELEPHONE CALL BOX.

being connected to arm E, the brush L to arm E', and the brush M to earth. D is the distant receiving instrument. The perforation for the brush M always comes between the perforations for the other brushes, and at a zero point. The black curved line with numbered indentations, in the lower part of the figure, shows graphically the waves of electromotive force, the impulses sent corresponding to the a-b-c of the Morse code.

APRIL 2.

671,311—W. Decker. Telephone Call Box.

This is a hand generator with two new points—a con-



671,403—WIRELESS TELEGRAPH SYSTEM.

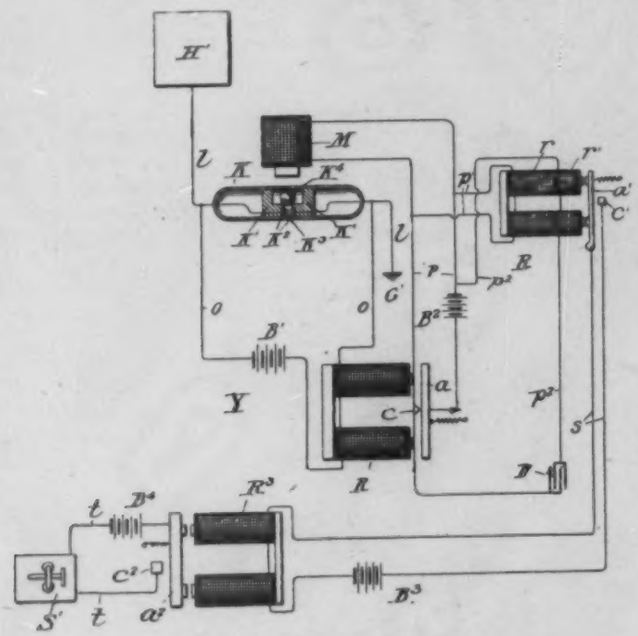
necting contact spring and a shunt. The spring is intended to obviate the difficulty heretofore experienced in getting at all the connections of a generator when mounted and con-

nected up in a box. It consists of a long punching E, with a tongue W formed in its body, and two holes to take the same screws that fasten on one of the hinges. It is applied with the part W over the lower box hinge, the long part E extending in to make contact with the end of the armature shaft, and the tongue fulfilling the usual function of the hinge tongues, insuring a good connection between the two leaves of the hinge.

The shunt is very simple. It consists only of a single strip commutator B, the strip being connected to the end of the armature shaft so as to constitute one terminal of the windings. A spring A is attached to a flange s on the frame O, and bears on the commutator. Twice in each revolution the armature is short-circuited, therefore, but as this occurs when the armature is at dead points, and no current flowing, it is no objection. Normally the armature sets with its mass across the pole pieces of the field, as shown, and the spring then rests constantly on strip B to maintain the short circuit.

671,403—H. Shoemaker. Wireless Telegraph System.

This is a system having one or two novel features. For both sending and receiving stations an aggregation of conducting plates supported parallel to each other is employed instead of a long vertical conductor. In the figure,



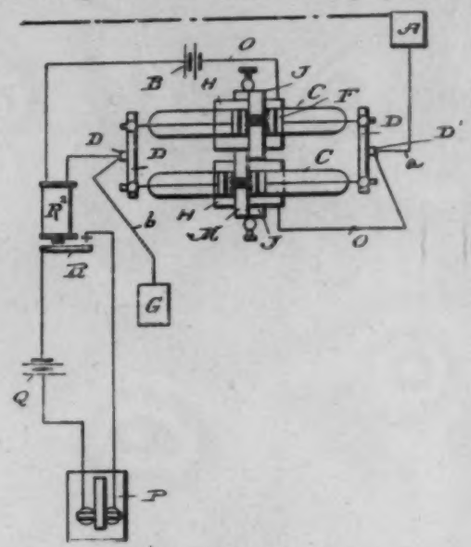
671,406—WIRELESS TELEGRAPHY.

which shows the receiving station only, these air plates 32-33 are shown as curved and rested within each other, being supported on a stand 34.

The arrangement of the receiving apparatus is substantially as usual. High resistances, 49, 50, 60, 61, are bridged across the local circuits to serve as a protection against high potential kicks, and doubtless to prevent discharges and consequent local disturbances of the coherer 37. The latter consists of a vertically held tube, sealed, containing wedge electrodes 39, 40, spaced apart by insulation so as to form a cup at their upper ends, in which lie the cohering filings, 47. Above the filings, and within the tube, is an insulating plug 44, with central aperture 45, carrying a soft iron ring 46. The entire structure is surrounded by a solenoid 38, having an iron ring core 38'. The solenoid windings are included in the local circuit with the sounder 55, and when current passes, due to breaking down of the coherer resistance and consequent working of relay 48, the solenoid, acting through magnetic ring 46, attracts the filings 47 upwardly, and causes them to decohere; thus replacing the ordinary tapper.

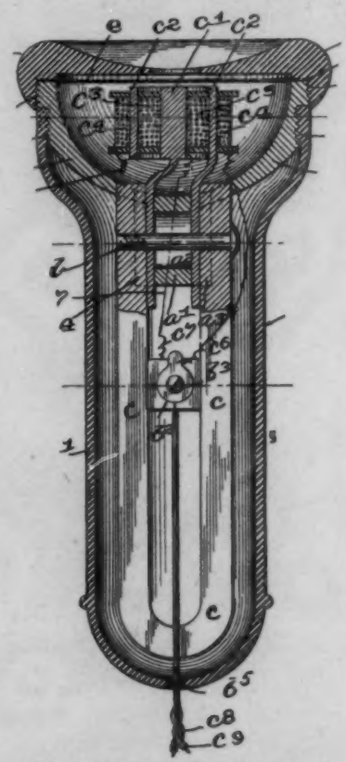
671,406—H. Shoemaker. Wireless Telegraphy.

Two points are presented as novel in this case. The oscillator terminals at the sending station are inclosed in a chamber containing "non-corrosive gas" under heavy pressure, instead of the oil or vaseline usually employed. Better and quicker operation is claimed for this arrangement. At the receiving station a scheme is employed whereby or-



671,407—WIRELESS TELEGRAPHY.

dinary dots and dashes may be taken by the second relay from the coherer. In the figure K is the coherer, having an iron ball K' inclosed in its tube and acted upon by magnet M to tap and decohere. R is the first relay, which at-



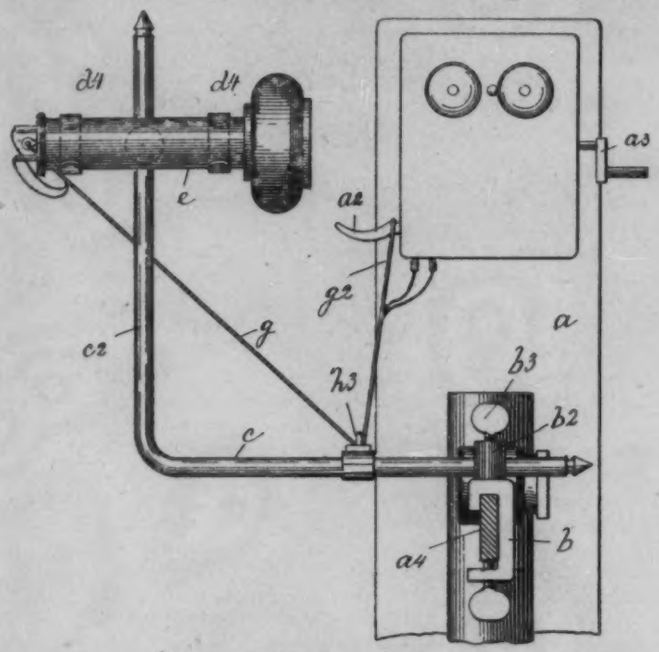
671,458—TELEPHONE RECEIVER.

tracts its armature a when the coherer acts, dots and dashes producing in armature a, a short and a long set of vibrations respectively. Relay R' takes these and translates them into plain short and long closures by means of an extra winding r', included in a condenser circuit p^3 around battery B^3. The condenser discharges keep the magnet

r r' excited, bridging over the short breaks between the vibrations of the same impulse. Relay R' acts on an ordinary sounder S' to give audible signals of the usual kind.

671,407—H. Shoemaker. Wireless Telegraphy.

The principal feature of this invention is in the decohering means employed at the receiving station. The coherer is double, having twin tubes C-C connected in parallel between supports D-D. Below the tubes are electro-magnets H-H with upturned poles M embracing both tubes.



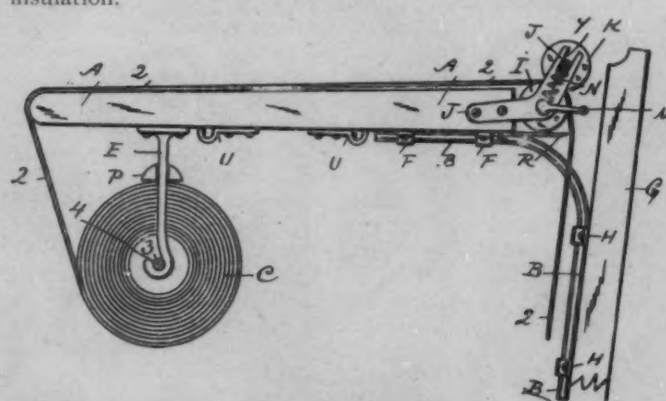
671,473—TELEPHONE RECEIVER HOLDER.

When current passes through the local circuits, due to the cohering action, these magnets H-H are energized to create a magnetic flux across the tubes at right angles to their length, thus raising the filings and decohering.

APRIL 9.

671,458—E. H. Strauss and F. J. Stein. Electric Telephone Receiver.

This receiver is bi-polar, with the well-known cup support for the magnet c c. The poles held separated by a distance block a', and connected thereto by a through bolt. One pole c', with its coil, is centrally positioned in the cup, and the other, c², surrounds it, with its own coil outside, at c³. The terminals are carried on a block b' of insulation.



671,577—TELEPHONE DESK.

671,473—T. Emerson. Holder for Telephone Receivers.

This is a bracket clamped on the transmitter arm a⁴ at b, with an adjustable arm c whose vertical member c² carries a sliding double clip d⁴ d⁴ for the receiver e. A cord connecting g passes from the receiver through an eye h² to the switch hook a³, holding the latter down when the receiver is up out of use.

671,577—C. E. Bartholemew. Telephone Desk.

This is a telephone desk carrying a paper roll c journalled beneath its front edge, from which the paper passes up over the desk front and back between spring-held guide rollers, then down over a cutter edge R at the back. It will be noted that the direction of movement is such as to permit continuous writing in the natural way, down the strip of paper, thus reversing the usual conditions.

OHIO TELEPHONE ASSOCIATION.

The annual meeting of the Ohio Telephone Association, which was held recently in Columbus, was attended by about 200 representatives of Independent telephone companies of the state. Judge J. M. Thomas of Cleveland presided and an interesting program of papers and discussions was carried out. The association re-elected the following officers: President, Judge J. M. Thomas, Cleveland; first vice-president, D. J. Cable, Lima; second vice-president, C. Y. McVey, Youngstown; secretary and treasurer, H. D. Critchfield, Cleveland.

The manner of taxing the companies for funds to carry on the work of the association was discussed and placed in the hands of a special committee, composed of Judge Thomas, Mr. Cable, Hon. Edward Kibler, Newark; Mr. Critchfield, Frank Davis, Columbus; Judge L. D. Hagerty, Columbus, and Hon. Harry M. Daugherty, Columbus. The association voted to pay $4,000 on the bill of $25,000 for legal services in the Berliner telephone patent suit. The manufacturers and operators of plants are to pay $12,000 of this amount, and Judge Thomas, at the meeting at Chicago, guaranteed the payment of $4,000 by the Ohio Association.

Several interesting reports were submitted, among them a report of the Citizens' Telephone Company of Columbus, which showed that it had 4,988 'phones in operation and 390 in course of extension. Henry A. Lanman of the local company, and Secretary J. Y. Bassell of the Columbus Board of Trade delivered the addresses of welcome, which were responded to by Judge Thomas. A vote of thanks was extended to the Citizens' Company for courtesies shown the visitors.

The Kansas State board of telegraph and telephone assessors has fixed the price at which the property of the companies in that state will be assessed this year. The new schedule of valuation agreed upon is a reduction from the valuation of last year of about 8 per cent. Telegraph poles and wire are assessed at $65 per mile for first wire and $10 per mile for each additional wire. First-class telephone toll lines are assessed at $40 for poles and first line and $6 for each additional wire. First-class telephone exchanges will pay taxes on valuation of $175 for each pole, $5 for each mile of wire, and $5 for each instrument. Second-class telephone companies using copper wire will pay on valuation of $24 per mile for poles and wires and $6 on each additional wire. Instruments of second-class exchanges are valued at $5 each, which is a raise of $2 over valuation of last year. Third-class exchanges will pay on valuation of 75 cents for each pole and $2 per mile for iron wire and $6 for copper wire. Instruments are assessed at $4 each, which is a raise of $1 over last year.

News has been received at Washington, D. C., from Minister Smith, who reports from Monrovia, February 26, that T. J. R. Faulkner, a civil engineer from the United States, has placed that city in telephonic communication with White Plains, a settlement 25 miles up the St. Paul's River. This is the longest line in the country.

Telephony.

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SPECIAL CONVENTION TRAIN.

TELEPHONY will run a special telephone train over the Lake Shore & Michigan Southern Railway to Buffalo on the evening of June 10 for the accommodation of those attending the fifth annual convention of the Independent Telephone Association of the United States of America, which will be held at the Pan-American Exposition grounds, Buffalo, on June 11, 12 and 13, 1901.

Many of the leading telephone manufacturers, supply houses and exchange managers in the West have made reservations to travel on this train. If you are going to Buffalo and desire reservation on TELEPHONY'S special telephone train, write at once, so that accommodations may be secured. A rate of $14.50 has been made from Chicago to Buffalo and return. Tickets good for ten days.

FIFTH NATIONAL CONVENTION.

The fifth annual convention of the Independent Telephone Association of the United States of America will be held at the Pan-American Exposition grounds, in the city of Buffalo, N. Y., on Tuesday, Wednesday and Thursday, June 11, 12 and 13, 1901. The sessions of the convention will be held in the convention hall banquet room, corner of Virginia street and Elmwood avenue, while the headquarters of the National Association will be at the Iroquois Hotel. Arrangements have been made by the Pan-American Exposition to carry members and visitors at one and one-third fare for the round trip. Mr. Samuel E. Wayland of Scranton, Pa., Robert R. Hefford and Clark L. Ingham, both of Buffalo, have been appointed a committee on arrangements for special rates at hotels, etc., for those attending the convention.

A special meeting of the advisory board of the National Association will be held at the Auditorium Annex, Chicago, on May 17, for the purpose of arranging the final program for the convention. The members of the advisory board are: James M. Thomas, Cleveland, O.; S. P. Sherin, Indianapolis, Ind.; Hugh Dougherty, Bluffton, Ind.; E. B. Fisher, Grand Rapids, Mich.; W. H. Durin, Cedar Rapids, Ia.; W. B. Seaton, Ashland, Ky.; George W. Beers, New York; H. D. Critchfield, Mt. Vernon, O.; Samuel E. Wayland, Wilkesbarre, Pa. The complete program will be given in the June issue of TELEPHONY. It is earnestly hoped that everyone interested in Independent telephone work attend this convention. These annual meetings are for the common good of the Independents, and the National Association should be offered every encouragement in its work. This publication believes that the best results are obtained through national and state associations, and that every man really interested in this work should be a member of both. The integrity and permanency of the Independent movement depends to a great extent on its organization, and many are coming to see the necessity for broadening and strengthening the national and state associations by giving both loyal support and advancing the interests of the common cause.

INDEPENDENT TELEPHONE EXCHANGES.

In October, 1897, the following was published in "The Telephone" as showing the status of the Independent movement up to that time:

INDEPENDENT EXCHANGES BY STATES.

"A great deal of speculation has been indulged in as to the number of Independent telephone exchanges in the different states. We believe the following list (which is the most complete and authentic in existence) will be closely studied by telephone men, as it covers every state in the Union and is corrected up to October 1, 1897.

"Independent telephony has made such rapid strides the past two years that it is next to impossible to keep track of the anti-Bell exchanges that are springing up in every section. Every stronghold of the monopoly is being successfully assailed and it is a matter of a very few years until this country will be network of Independent toll and long-distance lines, to say nothing of exchanges in every town and city. The futile attempts of the Bell people to hold their ground is amusing, and the fact that there are so many new local and home companies starting every month shows conclusively that at last the people have awakened to the fact that the telephone is theirs and they will not pay tribute for something that is free. It is interesting to note that the stronghold of Independent telephony is in the Middle West. Ohio is the banner state with one hundred and seventy-three exchanges; Illinois is a close second with one hundred and sixty-nine; then comes New York and Pennsylvania. These are the only two eastern states in the first seventeen. Seven of the states of the Middle West, namely, Ohio, Illinois, Indiana, Iowa, Michigan, Missouri and Wisconsin, show a total of nine hundred and seven exchanges,

which is considerably more than a third of the total number in the entire fifty-one states and territories. Ohio leads by a very small margin and will have to look to her laurels if she would keep in front. The complete list follows:

Ohio	173	South Carolina	24
Illinois	169	Oregon	22
New York	164	South Dakota	20
Pennsylvania	147	Colorado	18
Indiana	142	Louisiana	16
Iowa	139	New Hampshire	16
Michigan	133	Florida	14
Missouri	79	Connecticut	13
Wisconsin	72	Arkansas	12
Kentucky	69	Delaware	12
Georgia	67	North Dakota	11
Tennessee	64	Nebraska	10
Texas	64	Washington	10
Virginia	61	Oklahoma	9
Minnesota	53	Rhode Island	8
Mississippi	46	District of Columbia	8
California	46	Idaho	8
Massachusetts	43	New Mexico	6
New Jersey	39	Indiana Territory	5
Maine	39	Montana	4
Alabama	37	Wyoming	3
Maryland	35	Utah	3
West Virginia	32	Nevada	3
North Carolina	27	Arizona	2
Vermont	26	Alaska	1
Kansas	24		
Total			2,248

It seemed remarkable then that the Independents should have made such progress, against what were considered almost insurmountable obstacles. The record of Independent growth since then is still more remarkable. To-day there are approximately six thousand Independent exchanges, while the Bell Company have less than three thousand exchanges and branch offices combined. In the following list of exchanges by states it will be seen that Illinois has wrested supremacy from Ohio and leads with five hundred and five exchanges. There are many other changes, which may be readily seen by comparing the 1897 list with the one following. The Middle West, however, is still the stronghold, and will in all probability continue to be. The full list of exchanges in the United States on April 1, 1901, is as follows:

Alabama	45	Montana	19
Alaska	5	Nebraska	67
Arizona	8	New Hampshire	31
Arkansas	62	New Jersey	73
California	76	New Mexico	12
Colorado	25	New York	422
Connecticut	34	Nevada	3
Delaware	17	North Carolina	109
District of Columbia	5	North Dakota	26
Florida	31	Ohio	489
Georgia	119	Oklahoma	28
Idaho	8	Oregon	36
Illinois	505	Pennsylvania	402
Indiana	422	Rhode Isand	3
Indian Territory	19	South Carolina	73
Iowa	436	South Dakota	60
Kansas	137	Tennessee	125
Kentucky	121	Texas	181
Louisiana	18	Utah	3
Maine	63	Vermont	72
Maryland	69	Virginia	133
Massachusetts	53	Washington	21
Michigan	219	West Virginia	88
Minnesota	200	Wisconsin	213
Missouri	234	Wyoming	5
Mississippi	59		
Total			5,684

MODERN TELEPHONE ENGINEERING.

The leading article in this issue of TELEPHONY is a paper read by Mr. Kempster B. Miller before the New York Electrical Society on "Modern Telephone Engineering." We believe this paper will prove of more than usual interest to telephone engineers, as well as to those not so well versed on the technical side of telephony. Few writers are so well posted on telephone engineering as Mr. Miller, and the exhaustive manner in which he has treated his subject makes the paper a valuable contribution to telephone literature.

IT PAYS TO READ YOUR TRADE PAPERS.

To keep in touch with all the interests of one's business, to know at all times the status of the industry of which one's business is a fraction, to be informed as to wants of buyers and as to the goods of sellers, and to have a knowledge of one's competitors' progress, those are the guideboards to success of the most elaborate nature. No hermit ever accomplished great deeds. No narrow-gauged business man ever became a leader in trade.

Some tradesmen urge the excuse that much that appears in trade journals is neither important nor pertinent and that their time is so limited and their duties so exacting that they haven't the spare hour in which to read trade publications.

Let us grant, for the sake of argument, the uninstructive and irrelevant plea, and ask whether it is better to miss the knowledge of important and pertinent matters, because this is so, or to secure the benefits to be obtained from important and pertinent items, even at the expense of reading, in search for the useful, something that isn't so all-important. There is no gold mine without its full share of unprofitable dirt. There is no course of instruction without its full quota of dry and almost meaningless pages, and there is no road to success without its more than essential rocky steeps and thorny fringe. Just so, there is no trade journal that is all instruction and all rich advice. Were it so, trade journals would sell at a dollar a copy, and trade journal advertising space would be as costly per square inch as $100 bank notes. Were it so, trade journal editors would rank as twentieth century Solomons, and trade journal publishers would be as unapproachable as the Czar of all the Russias.

As for the item of time, the excuse is no excuse. If you haven't time you should take time, just as you take time for every other business demand. And don't dodge duty by delegating to a clerk the reading of the trade journal. The head of affairs may delegate much labor to assistants, but he cannot delegate brains to anyone, and it is brains that count. No two men place the same estimate on the value of any idea, suggestion, or item of news. A paragraph that is trivial to Brown may be a gold mine to Smith, and vice versa. And so, if the head of affairs desires to keep in touch with his industry he can ill afford to trust to a clerk's idea of the worth of this or that idea in a trade publication, but instead must read and weigh for himself, and, reading, he will find that it is the trade paper that strengthens and broadens his field, makes a market for his product, or at least discovers one, keeps him in touch with the buyers, etc. A manufacturer should read his trade paper, he should support it by advertising, and the time and money so spent will prove most profitable.

J. M. C. writes to know if the Bell people still hold the patents to the loop system described in the question and answer column of April Telephony and also if this system can be applied to any bridging bell.

The editor does not know whether the Bell people still hold the patent rights to this system, but as it is an old idea it is rather doubtful whether they can hold it, even if they do make the claims.

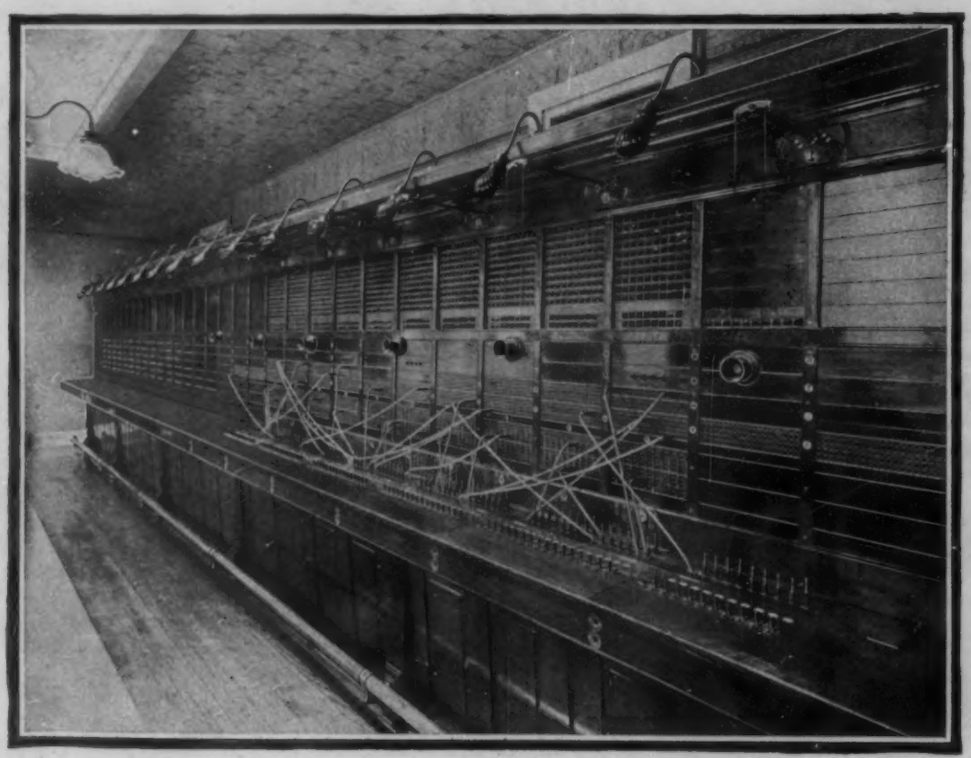
THE NEW EXCHANGE AT SANDUSKY.

Probably no exchange in the independent field has come out with as varied and perfect a service to its patrons as that which the Sandusky Telephone Company announces at the opening of its new exchange this month. Not only new features in the matter of equipment are offered, but also innovations in service as handled by the Independent people. Amongst these latter are special features, such as measured and pay-station service.

MANAGER CURTIS.

The Sandusky Telephone Company was organized in 1895 and opened the first exchange in October of the same year with about 300 subscribers. At that time the older company had about 350 subscribers, which list had been considerably inflated by the efforts on the part of their solicitors during the period of construction and installation of the new exchange. Like most independent companies embarking in the telephone business at this period, the common mistake of not providing sufficiently for the future was made. The exchange had scarcely opened for service when it was found they were up to the limit of their equipment and outside construction. Immediately the plant was rebuilt and reequipped for a capacity of 500 lines. Two years of service and growth found them again up to their limit. At this time a switchboard with 600 drops was installed, the same being of the express type, and later on two additional sections of 100 drops each were added.

REAR VIEW OF BOARD.



2,400 CAPACITY SWITCHBOARD—1,000 LINES INSTALLED.

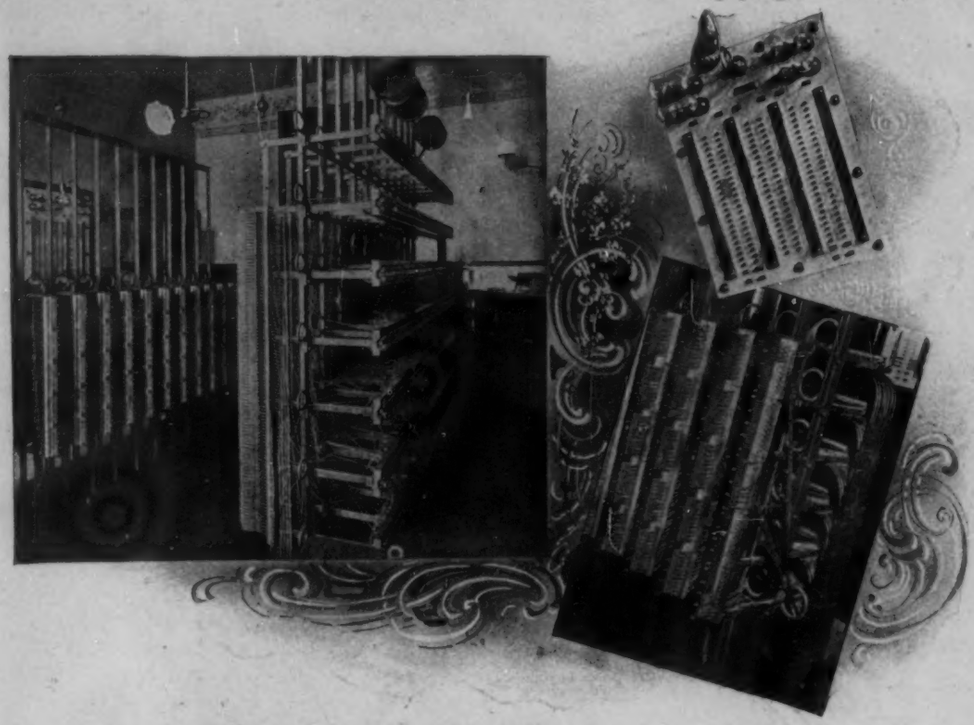
This brought the equipment up to a capacity of 800 lines, which was the capacity at the time of the present reequipment.

Prior to this period the business had been handled, as is often the case among the smaller independent exchanges, by the board of directors, without any special attention being paid to having competent and efficient management. When the plant had reached almost its full capacity, the board of directors realized the necessity of a master hand having full control of the business, and after considerable negotiation Mr. Carl C. Curtis was secured and given complete control, with instructions to rebuild his plant and reëquip same with the best that money would buy. Considerable investigation satisfied both the new manager and the board of directors that the most feasible course was to reconstruct their outside plant and install some character of supervisory multiple switchboard. Exhaustive investigation resulted in the placing of an order with the North Electric Company of Cleveland, Ohio, for complete equipment with an up-to-date central office, and the replacing of all subscribers' instruments with those of latest design and especially fitted to work with the system to be installed. The manufacturers were given carte blanche to leave no stone unturned to give the Sandusky Telephone Company the latest and most up-to-date equipment.

After careful consideration of the various types of central battery systems, the Sanduskians came to the conclusion that a central signal supervisory multiple switchboard involving the use of local talking batteries at the subscriber's instrument, would give the highest grade of service and at the same time the minimum of operating and maintenance expense.

The first connection with the new system was made

about the first of February of the present year, the service being gradually cut over from the old board to the new without interruption in service of a single line. The last connection on the old switchboard was cut over on the 11th of April and since that time the character of service has steadily improved much to the satisfaction of patrons.

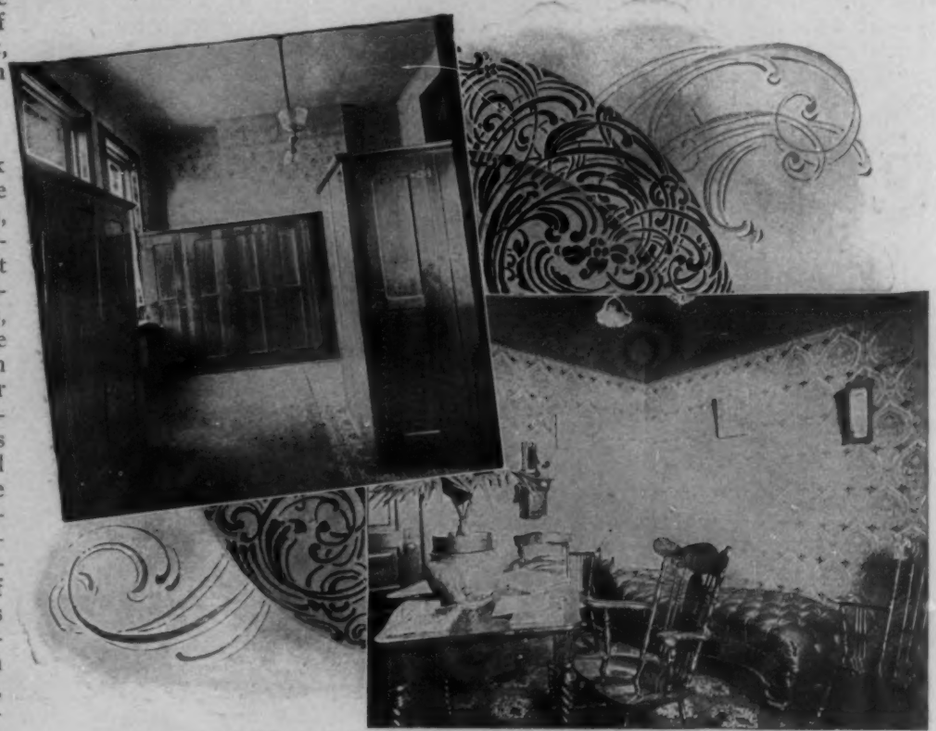


TERMINAL ROOM. FUSE BOARD—NEAT CABLING.

The work of outside reconstruction is not yet complete, the present plan being to make the same on the basis of a future list of at least double the present plant, which provides for an installation of 1,000 lines.

THE SWITCHBOARD.

The switchboard is one of the six panel multiple type, having double supervision in the cord circuits, and using a target signal in preference to one of the electric light type. The frame capacity and partial installation is for 2,400 lines, while complete installation is made for 1,000 lines. As the population of Sandusky is considerably over 20,000, it will be seen that the additional capacity planned for is wise. In examining the central office equipment, and especially the main switchboard, surprise is occasioned at the simplicity of the apparatus used in accomplishing results that usually require the use of many complicated parts. In this system there are no relays or condensers in direct connection with the talking or signaling circuits, either in the subscriber's instrument or central office.



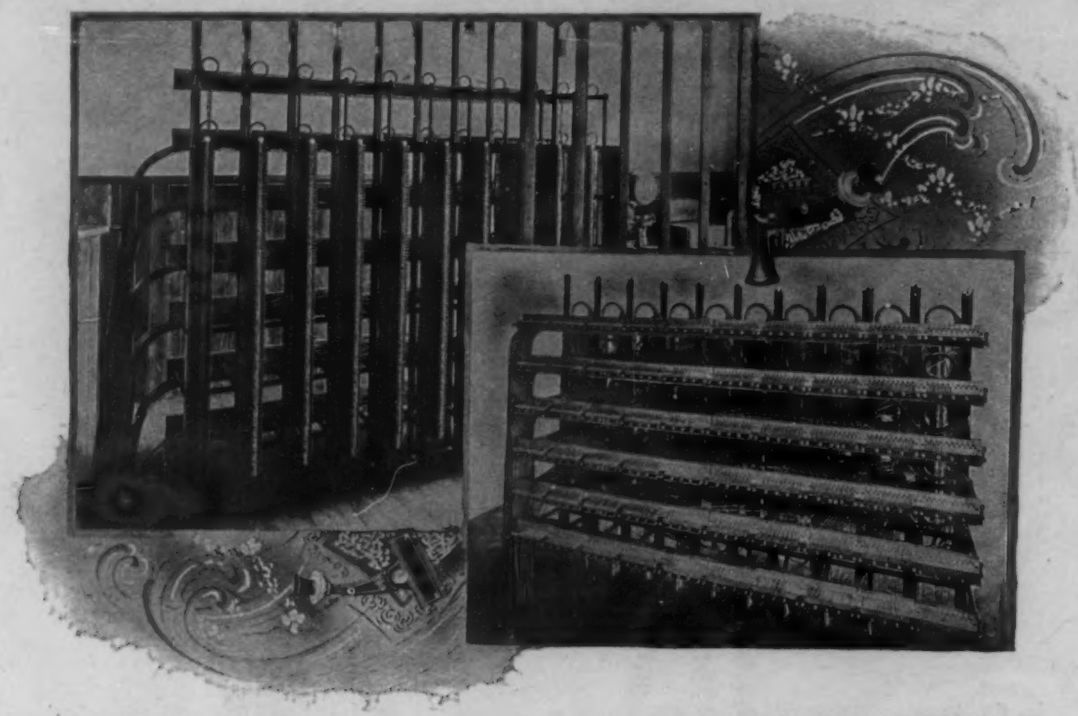
LOCKER ROOM. LOUNGING ROOM.

OPERATION.

The subscriber, in order to signal the operator, merely removes the receiver from the hook, the result being the display of a target signal on the switchboard, which automatically returns to its place on the operator answering by inserting a plug into the jack of the line signaling. The operator, on obtaining the number, inserts the corresponding plug into the jack of the line desired, rings same, a target being exposed on the cord circuit until the called subscriber responds. In the event of the subscriber being tardy in answering, the operator is enabled to ascertain that no answer has been received and rings the party one or more times thereafter without having to cut in on the line to ascertain whether the party has received an answer. On the completion of a conversation, when either one or both of the subscribers return the receiver to the switch hook, the supervisory signals in the cord circuit, one for each subscriber, is displayed. In the event that either subscriber desires a subsequent call, he can gain the attention of the operator without the operator having to disconnect and get the signal through the line target, she being advised of the desire for subsequent calls on the part of the subscriber by the failure of his supervisory signal to display a disconnection or by the subscriber pumping his hook up and down slowly, the target signal being displayed each time the hook is operated. *It will thus be seen that the operator at no time has to cut in on the cord circuit, except to ascertain the number of the party desired, she being automatically informed at the time the called subscriber answers, when said subscribers have finished a conversation, and when either subscriber desires subsequent calls.*

The chief operator's desk is equipped with signals, monitor lines and an intercommunicating system, she be-

ing able to make observation on the work of the operators as well as take care of all the detail which has been inaugurated for the purpose of securing data necessary to obtain the highest efficiency in service. The chief has complete control of all the operators, securing a grade of discipline that is not usually present in independent exchanges.



MAIN DISTRIBUTING BOARD.

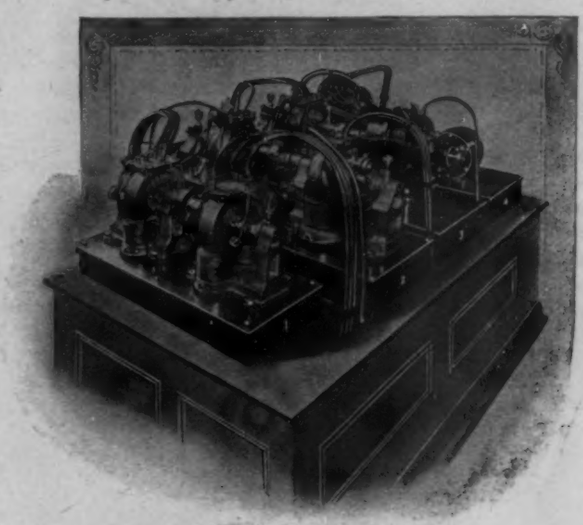
INTERMEDIATE DISTRIBUTING RACK.

An interesting feature is the observation lines which are in connection with the chief operator's desk, the purpose of same being to allow the chief operator to observe the service of any particular lines which are, for any reason, brought under surveillance. Every time a connection is made involving the use of the observed subscribers' lines, an auxiliary signal is given on the chief operator's board, she cutting in and making a record of such features of the service as may be necessary, owing to the character of the observation required. This proves an efficient method of handling the "chronic kicker," who is invariably present in connection with all exchanges.

TURNING SECTION.

Off the operating room are located the terminal and toll rooms. The toll operator is able to get connection, through the distributing operator, with all lines in the exchange and has at her command a feature that has never been used, except by two Bell exchanges. This special feature is known as the "busy back test," sometimes called the "tone test," the function of which is to compel the reservation of a line that may be in use at the time the toll call is received, so that the operator will get the line immediately after the completion of the local connection then in vogue. When the "busy back test" is on a line any operator testing the same gets a "tone test," which is entirely different in character from the "busy test," she thus being informed that this line is wanted for long distance connection. The toll operator is also automatically notified as soon as said subscriber's line is free for toll connection. The intercommunicating system gives direct communication between the different departments, viz., the manager, chief operator, wire chief, power room, and various departments in the office. It has proven itself of the utmost convenience.

In the terminal room is located the main distributing board, intermediate rack, wire chief's desk, with the testing apparatus, the fuse board, etc., this department of the exchange being in direct charge of the wire chief. The main and intermediate distributing board are both of steel and of the open rack type of construction, the outside cables

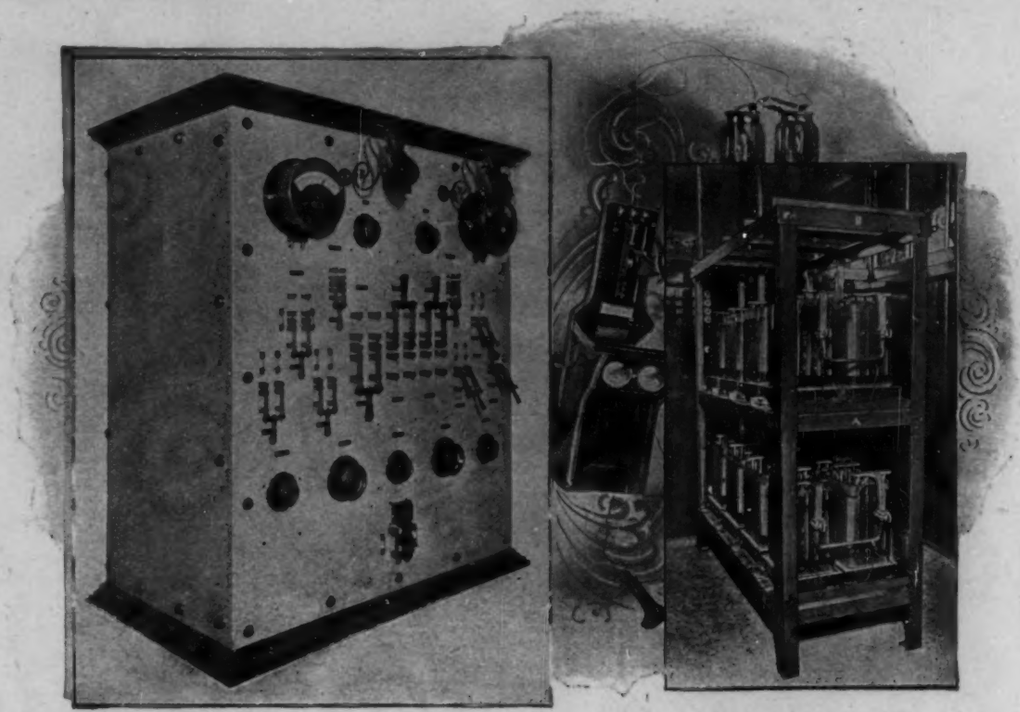


MOTOR GENERATORS.

being brought direct to the line side of the main distributing board, from whence it is cross connected to the switchboard side, on which are located the protectors for lightning and strong and sneak currents, said protection being of the Cook type. From this point the lines are cabled to the multiple jacks, then back to the intermediate distributing rack, and from that point to the answering jacks and line signals.

The function of the intermediate distributing rack is

to enable the distribution of the busy lines among the various operators without changing the number of the subscriber, thus putting an even operating load on the different operators and securing maximum results from the operating force. This feature, together with the double supervision on the switchboard, enabling the operator to do away with much of the work usually required on the switchboards not having the supervisory feature, enables this exchange to give the very best grade of service with 200 lines to the operator. One of the cuts shows five operators handling 1,000 lines, and tests made by the stop watch show an average of about three seconds on all calls received in the entire exchange, many calls being answered too quickly to be recorded. The average number of calls received in this exchange between 7:30 a. m. and 5:30 p. m. is eight and nine-tenths calls per line for the entire exchange. When it is realized that this is the average for ten hours only, it will be seen that the service is very speedy. The operators claim that they have less trouble in handling 200 lines with the new system than they had with 100 lines in the old. In fact, many of them claim that they could handle from 25 per cent to 50 per cent more lines without any embarrassment whatever. Special tests under unnatural conditions have shown several operators handling nearly 500 calls in one hour with an average considerably under five seconds in the entire test. The



POWER BOARD. STORAGE BATTERIES.

FIVE OPERATORS HANDLING 1,000 LINES.

Sandusky Telephone Company is the first in the independent field that has had sufficient nerve to tackle the operation of 200 lines to the operator on a multiple switchboard and they have demonstrated to their entire satisfaction that they would have been unwise in attempting to operate less lines per operator.

PRIVATE BRANCH EXCHANGE BOARDS.

On a broad base, filled with sand and standing near the center of the power room, are four motor generators, busy transforming the 500-volt direct and the 104-volt alternating currents from the electric light station into the lower voltage currents required for ringing the subscribers and charging the storage batteries.

They run at high speed—2,500 revolutions per minute; their "whirr" is scarcely audible outside of the room and there is no floor vibration whatever, so accurately balanced and mounted are they. The machines are provided in duplicate for reserve in case of accidents. At one side of the room is a handsome marble power board, with a dazzling array of burnished copper switches, Weston ammeters and volt-meters used in regulating the machinery. The floor is of polished oak and, like everything else about the exchange, is kept as spick and span as constant attention will admit.

The storage batteries, in duplicate, are in a small room partitioned off at one side, while at the end is a coat room for the use of the switchboard men.

Operators of central battery plants will be interested in learning that one charge of batteries gives five days of service, the duplicate set requiring charging only once in ten days. The first month, when more than the usual amount of current was being consumed, the cost of the current for operating was about $4, the bill for the second month being materially less. This substantiates one of the claims of the manufacturers, viz., great economy in consumption of current.

This company is very careful of the comfort and well-being of its employes, and with this end in view has provided within easy access of the operating room a cozy lounging room, furnished with easy chairs and divan. On the table are found the current magazines and papers. Next to this room is the locker and toilet room, which contains an individual locker for each operator.

CHIEF OPERATOR'S DESK.

TYPE D.

WALL SET.

SERVICE METER.

DISCIPLINE

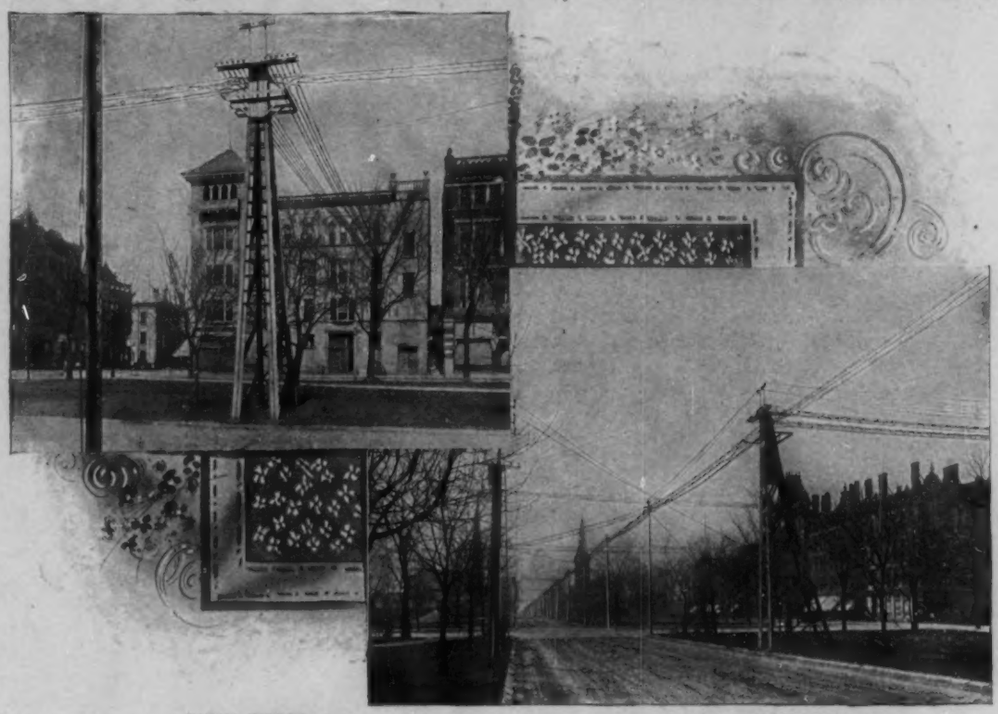
It would pay the managers of many exchanges to make a visit to the Sandusky Telephone Company's new plant, if for no other reason than to observe the high grade of service attained through the discipline which has been in-

augurated by Manager Curtis. Mr. Curtis has always held that an efficient operating force is the mainstay of the exchange, and in order to get the best it is necessary to get the most thorough and complete discipline.

In the first place, utmost quiet must prevail. Such a thing as the operators chatting with each other would not be tolerated for a moment. They must sit erect, facing their positions, and the turning of a head or the raising of a voice louder than a hoarse whisper is sufficient to provoke a sharp reprimand from the chief. Their conversation with subscribers must be kept well within a prescribed limit and any operator detected in overstepping the boundary is required to explain its cause satisfactorily to the chief or suffer the consequences. Patrons desirous of asking for information or making complaints should call for the "chief operator." Operators at the board are allowed to indulge only in such conversation as is necessary for making regular connections.

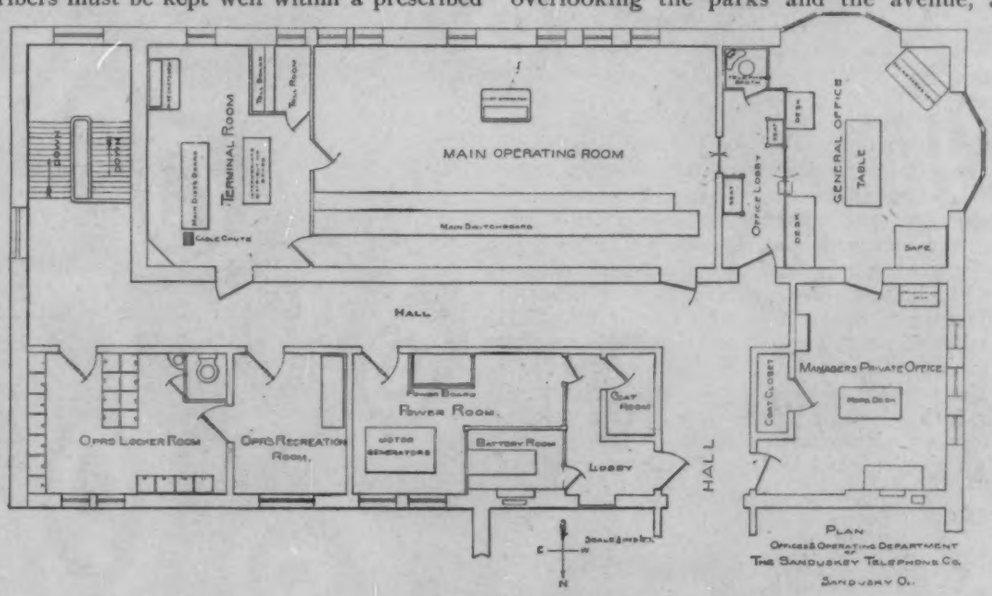
The change of shifts at morning, noon and night is made on signal, and is conducted with all the precision and exactitude of a military drill. Only certain specially designated employees are permitted in the operating room and they only when their duties demand.

Several large suites on the fourth floor of the Kingsbury block have been remodeled to suit the requirements of the business offices and operating department.



CABLE TOWER. IRON POLE LINE.

At the right, as you enter the lobby, is the general office, with Secretary Arthur C. Arend in charge of the clerical force. This is a bright, sunny, corner room, overlooking the parks and the avenue, and is finished in white enamel, with fixtures and furniture of polished oak. Adjoining the main office and similarly furnished, but carpeted, is the private office of the manager, Carl C. Curtis. His desk is provided with a monitor and a complete intercommunicating system, in addition to the regular exchange lines. The monitor enables him to "keep tab" on "the telephone girl," while the intercommunicating system brings him into instant communication with the



FLOOR PLAN—FOURTH FLOOR.

heads of departments direct, without calling through the exchange.

To the left of the lobby is the main operating room, finished in white enamel, with polished oak floors, and fixtures and furniture of the same wood. Rubber matting is placed wherever there is much walking to be done, insuring quietness. The room, which is a long one, is flooded with light from numerous windows, and the skylight above. The switchboard, extending down one side of the room, is thirty-three feet long, and seven high.

The chief operator's desk is placed on the opposite side of the room and commands a view of each operator's position; the work of each is closely watched and connections timed by means of the pilot lamps which glow whenever the exchange is called.

The terminal, toll and power rooms have polished oak floors and are furnished for their several requirements.

On the third floor are the stock-room, shop and inspector's quarters. Repair parts, telephones and wire are kept in the first, repairs and special apparatus are made in the second, while the third is arranged with individual lockers, and seats for the inspectors while awaiting assignments for duty. In the basement all heavy construction tools and materials are stored, a large stock of wire, insulators and hardware being kept on hand.

A careful record is kept of all complaints of service, by the chief operator, and from her report a second record is made by the wire chief of such trouble as pertains to his department. These reports are filed in the manager's office and indexed in such a manner that a complete detailed report can be had of all the trouble or complaints originating at any particular telephone.

At stated intervals careful tests are made of speed of service rendered by the different operators, putting a "stop watch" on calls and carefully tabulating the results. Where the operator's work shows it is falling much below the average she is notified of the fact and unless improvement follows, her resignation is required. Special apparatus for the purpose of making these tests is located in the terminal room and the operator never knows at what time her work may be brought under surveillance.

Once a week a "peg count" is made of the number of calls each hour in the day for each operator. These indicate to the chief operator whether the character of the service of the exchange is changing and whether any operators are overworked, while their neighbors may have capacity for more busy lines. Where shifting conditions of service may result in overloading any operator, some of the business is diverted by means of the intermediate distributing rack, to a less busy section of the switchboard. From the data thus obtained is also plotted a curve on a chart which shows at a glance the complement of operators required to handle the service at various times in the day. In the case of excessively busy lines a record is kept of the number of times each line "tests busy" so that at the end of each month a report can be rendered those subscribers of the number of calls which they have missed owing to their lack of sufficient telephone accommodations at their places of business.

A "don't answer" record is kept of all uncompleted connections where the calling party waits for the operator to repeat "don't answer." No record can be made, however, unless the subscriber stays on the line until the operator exhausts all means in her power for obtaining an answer from the party wanted. When repeated "don't answer" calls are recorded against a subscriber a trouble report is made and the cause of the "don't answer" investigated.

Through connection with the United States Telephone Co. (long distance) and other toll lines, they are enabled to give connection with 1,500 cities, towns and villages located in several states. This service is largely over copper metallic circuits with a mileage of 25,000 miles of the best construction and at reasonable rates. Unlimited, measured and nickel pay station service is offered. The rates apply only for distances not exceeding one and one-half miles from the exchange.

UNLIMITED SERVICE.—Payable monthly: Business, $30.00 per year; Residence, $18.00 per year; Extension 'phones, $9 to $12 extra per year, depending on length of run.

MEASURED SERVICE.—Payable pro rata quarterly: Six hundred calls (outgoing) per year, $12; Extra calls, 5 cents each; Calls are registered by subscriber at meter on the 'phone.

NICKEL PAY STATION SERVICE.—Five cents per call (outgoing); Subscriber guaranteeing at rate of $12 per year; Settlements made quarterly.

Plans are being perfected to extend the service throughout the county. It is handled to best advantage from sub-exchanges and toll stations.

Engineers will be interested in the cable tower and iron pole construction carrying the cables through the park. Each has capacity for carrying the strain of several times the cable used. Both tower and poles are set in cement.

The illustrations for this article are from a souvenir issued by the Sandusky Telephone Company, who will forward same for two cents for postage.

POINTS ON THE B. & S. WIRE GAUGE.

It is often convenient to be able to determine the approximate resistance of a wire without it being necessary to hunt up a wire table, says "Science and Industry." In the B. & S. wire gauge the rule by which the sizes of wire increase as the gauge numbers diminish is quite simple. If we take any gauge number as a basis of comparison, then by adding 3 to the gauge number we obtain the number of a wire having very nearly ½ the cross-sectional area. To illustrate: One No. 7 wire will have the same cross-sectional area as two No. 10's, as four No. 13's, as eight No. 16's, and so on. Similarly, by subtracting 3 from any gauge number, we obtain the number of a wire having very nearly twice the cross-sectional area. Thus, No. 1 has twice the area of a No. 4: No. 10 has twice the area of a No. 13. A little study will show that the ratio between the area of each wire and the next smaller is equal to the cube root of 2, or 1.26, for in order to obtain the size of a wire of twice the area of a given wire, we must multiply the area of the given wire by this ratio three times; therefore the cube of the ratio must be equal to 2.

The resistance of a wire varies inversely as its cross-sectional area. A wire three sizes smaller than a given wire will have a resistance twice as great, and a wire three sizes larger will have a resistance one-half as great, as that of the given wire. The ratio between the resistance of any wire in the B. & S. gauge and that of next higher number is that of 1 to 1.26. The ratio between the resistance of any wire in the B. & S. gauge and that of the next lower number is that of 1.26 to 1. To illustrate the manner of using the above rules we will solve the following example: The resistance of a No. 00 B. & S. gauge copper conductor is .411 ohm per mile. What is the resistance of a similar conductor of No. 3 gauge?

Solution.—The third size smaller than No. 00 is No. 2. The resistance of No. 2 per mile is, therefore, $2\times.411=.822$ ohm. The resistance of No. 3 is 1.26 times that of No. 2, or $.822\times1.26=1.036$ ohms. Ans.

It is a convenient fact to remember that the diameter of a No. 10 wire in the B. & S. gauge is very close to 1-10 of an inch (.10189), and that its resistance per thousand feet is practically 1 ohm (1.0199). For rough values, one can, by remembering these facts, compute the resistance in cross-sectional area of any other size in the B. & S. gauge without using a table. For accurate calculations, however, it is always better to consult a table giving the various properties of different sizes.

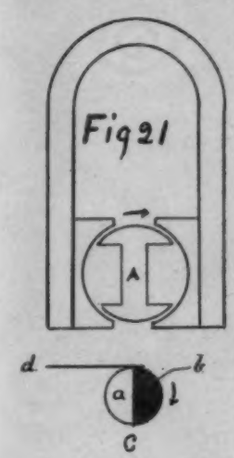
ILLUSTRATED COURSE IN TELEPHONY.

CONDUCTED BY W. A. TAYLOR.

Telephone Troubles and Their Remedies.

In putting in station arrester mounts trouble will likely be caused if the connecting wires are wound into "pig tails." Bring the wires as directly as possible to the arrester without unnecessary kinks or bends. The line should first go by the arrester and then to the instrument. The spiral or pig tail which is often found in the connections to arresters presents a high impedance to rapidly oscillating currents, such as lightning, preventing it from taking to the ground wire; thus the arrester does little good in protecting the instrument. If the coiled wire is to be placed anywhere let it be on the connections next to the instrument; then there will be a tendency to choke the lightning back from the instrument and force it to the ground through the arrester.

Pulsating Current Magnetos.—These generators are used mostly on party lines in order to call the central office without disturbing the rest of the bells on the line. In these generators the current is generated during only half the revolution. One contact is made on the body of the generator and the other on a semi-circular contact or a collector ring. This collector ring sometimes gets twisted and thus sends an alternating current. The method of setting is shown in the figure (21). A represents a cross section of the armature; C is the commutator; a is the contact part and b the insulated part; d represents the brush. Now when A is in the vertical position as shown there will be no current, but as it revolves in the direction shown by the arrow, the current begins to rise. So when the current is zero the brush should be on the point of passing from the insulated part of the ring to the contact part; then as the armature turns over the full effect of the current will be received from one pole while the inducing effect of the other pole is cut off when the brush passes over the insulation. So, in short, in order to set the collector ring properly, set it so that when the armature is in a vertical position the brush will be on the point of passing from one part of the ring to the other. If after this adjustment any of the bells on the line will ring it is an indication that they have their connections reversed. The bells used in connection with these magnetos are biased, that is, they have a light spring which holds the clapper against one pole of the ringer coils. Unless the current is reversed a current passing through the coils only tends to hold the armature tighter in the normal position.

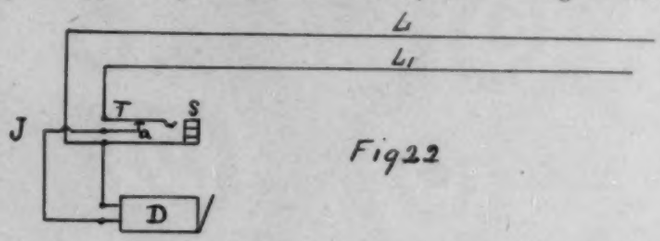


Condensers.—In most forms of common battery instruments there is a condenser generally of 2 microfarads. The condenser is put in in order to prevent the battery flowing through the bells when the instrument is not in use. It will not, however, interfere with the ringing of the bell by alternating current. The condenser is also used in order to produce a better quality for talking. The condenser insulation is sometimes punctured by a spark of lightning, and in that case the signal is thrown in the office, though the bell is wound so high in some cases that sufficient current cannot flow to make any signal. However, a flow of current will occur which, while it may not be bad in a single case, would cause a bad waste if a number of such leaks occurred.

To test the condenser connect a receiver and battery in series with it. Upon making the connection a click will be heard in the receiver, but by making a number of contacts in quick succession the clicks will die out after the first two or three contacts if the condenser is good; but if short circuited there will be a strong click each time. A short-circuited condenser will not affect the transmission. If a condenser is short-circuited it frequently can be fixed by connecting in series with a battery current which will give a high current, or an incandescent light current. A heavy current passing melts the tin foil at the point of short circuiting and at the same time separates it, allowing the paraffine insulating to run between. The method is called "flashing." If flashing does not help the condenser had better be thrown away as it is hardly worth the time to take it apart. In case one of the condenser leads is opened inside the box it can neither be talked nor rung through.

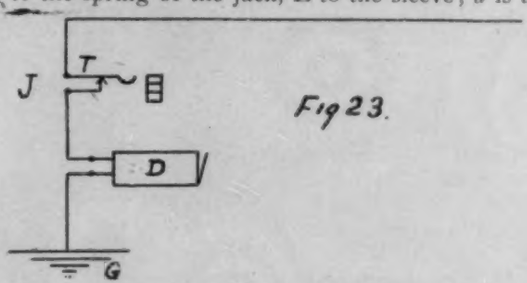
THE OFFICE.

Arresters and Protectors.—All lightning arresters should be examined after every electrical storm for grounds. This applies especially to the arresters, consisting of two blocks of carbon separated by a thin strip of insulation. The lightning discharge frequently carries bits of carbon across and completely grounds the line. The writer has known cases where all the conductors in the cable have been completely grounded from this cause alone. This form of arrester is extremely efficient when kept in good shape, but otherwise is only a source of trouble. The fuses and heat coils should be inspected regularly every morning and all defective ones replaced.



The Switchboard.—It is essential that all trouble here should be remedied as soon as it appears, as trouble in the board is apt to throw out the greatest number of lines.

The figure (22) represents the subscriber's circuit in the ordinary metallic circuit magneto-signal switchboard. L and L are the two lines coming into the office to a jack, J, L going to the spring of the jack, L to the sleeve; *a* is a local spring which normally is in contact with the line spring. A line to the drop D goes from *a*, and another line connects the sleeve of the jack to the drop. When an impulse from a subscriber's instrument comes in, it will pass through the drop, throwing it and indicating the call. When the plug of the cord is inserted into the jack, the line spring is lifted from the local spring and disconnects the drop. The difference between this circuit and a grounded circuit is that instead of line L there is the ground G. (See figure 23.)



Drop Does Not Fall, Cannot Talk Either Way.—Examine connections on distributing board and on spring jack. The circuit will be found open at the connection or the connecting wire broken. However, do not unlace the cable except as a last resort. Another cause for this trouble may be a short circuit which will be apt to be found either in the distributing board jumper wires or in the spring jack. In a board which is kept in good condition there is rarely any trouble in the cables.

Drop Does Not Fall but the Talking is All Right.—The trouble is in the local circuit and may be due to bad contact with the local spring of the jack, an open joint

or open or short-circuited coils. Try to throw drop by current directly applied to terminals of the drop. If drop throws all right the connecting wires may be open; if drop does not throw, disconnect the connecting wires and try again. If the drop throws then the connecting wires must have been short-circuited. If the drop still refuses to fall it is either open, short-circuited or badly adjusted. First examine the adjustment and if that is all right the coils are bad.

Drop Falls When Connections are Up.—The spring of the jack is not lifted from the local contact.

In common battery signalling practically the same circuit is used, but with the following modification: Figure 24, the signal is sent out over L and through the drop D to ground through battery B. If none of the drops will fall

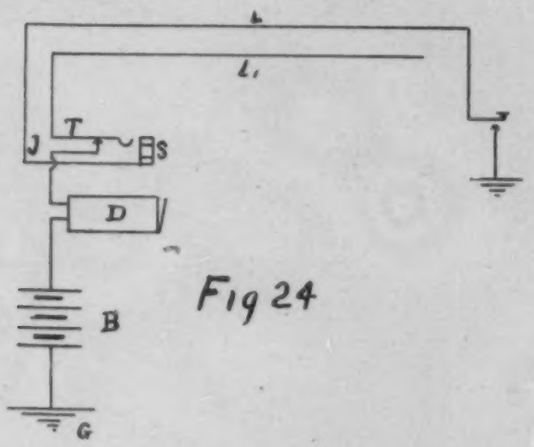


Fig 24

the battery connection to the board or to the ground is open or the battery run down. If the drops on a single section refuse to work, the common battery wire of that section is disconnected. If a single drop refuses to act, test as in magneto board. The drop remains down. The ground is on the line L. Care should be taken in this system to always have the battery in good working order and a perfect office ground. There should always be a reserve battery connected to a double-pole double-throw switch so that either battery may be quickly thrown on to the lines.

The Cord Circuit.—Figure 25 represents a metallic cord circuit and operator's circuit complete, as is generally used on switchboards of the magneto type. A is the answering plug. B is the calling or connecting plug. M is the generator, R operator receiver, T is the operator transmitter, B is the transmitter battery, P is the primary of the induction coil, S is the secondary of the induction coil. In ringing, the signal is sent over the connecting cord by pressing a button or lever E, closing the contacts a and b, at the same time opening the answering cord. This act disconnects the answering cord, so that it is impossible to ring through the operator's circuit, or into the calling subscriber's ear. There is another circuit whereby either cord may be used for calling, in which another ringing button is included in the answering cord in exactly the same way as just described for the calling cord.

When the operator wishes to listen she presses the lever or button L, which makes the contacts c and d, and thus cuts her secondary circuits across the cords.

The following are some of the troubles experienced on the cord circuit:

Cannot Ring.—Examine connections and contacts on ringing key; they may be open. Cord circuit may be open or short-circuited; if so, there can be no transmission. The first step will be to find if the current is at the contact, either by placing the fingers across the circuit or testing with the bell; if the current is not present trace the leads back for an open or short circuit. If the main wires from the generators are in trouble the whole board will be affected. If the trouble is in the key, due to a bent spring, it is better to put in a new one, for the bending is generally due to imperfect tempering. If the trouble is due to bad contact from dirt, slip a piece of clean, tough paper between the platinum contacts, then allow the springs to come together and pull out the paper. Do not under any circumstances use sandpaper, emery cloth or a file on this work. Where the contacts are hard to get at a good way is to take a very thin piece of clock spring, file it crosswise with a medium fine file, so as to take the smooth glazed surface off, and use this in place of the paper. This spring will give very good satisfaction and not unduly wear down the platinum contacts. Where any kind of sandpaper or cloth is used trouble will be experienced from the sand getting into the parts. If there are any keys without platinum contacts they should be removed, as they are a constant source of trouble, especially in the cord circuit. A short or open circuit may be located in the cords by the same method as explained for receiver cords.

Talking Circuit.—The whole board dead, operator can hear, but not be heard.—Examine battery for bad connections or for internal trouble, due to a battery run down. The battery leads may also be short-circuited. The transmitter may be short-circuited (see subscribers' telephone circuit for method of testing).

Transmitter alive, but can talk to or hear no one.—There is strong side talk in the receiver. The trouble is probably caused by a short circuit in one of the cord circuits. To find the trouble, open all the listening keys, then cut them in one by one till the trouble occurs, then the short will be found in the circuit of the last listening key, which was thrown in. If the strong side tone remains in the receiver when the keys are all thrown out of the listening position the chances are that the common wires from the secondary circuit are crossed, probably at the key connections. If the trouble is in a cord circuit, test each of the cords for a short circuit, which may be either in the plug, the cord itself or the wire connecting the cord with the listening key, or even in the listening key.

Cannot call or talk over a certain cord.—Not short-circuited. The cord must be open. Examine the ringing key contacts. If all right, examine cord for broken strand. A scratching or grinding noise and cutting off are caused by imperfect key contacts or a worn-out cord. There should be an extra jack on each section for testing cords, the tip

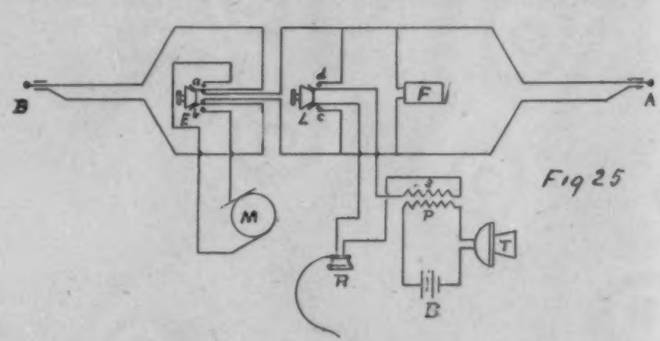


Fig 25

and sleeve of which should be connected to the terminal of a cell of battery. By inserting the plug of a cord a broken tinsel or wire or defective key may be detected by the grinding noise when the listening key is pressed. If the defect is near the plug the fault may be remedied by cutting back the cord. To locate the point of the fault hold the cord at a point about six or eight inches from the plug, so that the six or eight inches cannot move, then shake the remainder of the cord; if the scratching occurs, take hold a little farther down, continuing till the point of the trouble is found. If this point is near enough to the plug to permit cutting back without shortening the length too much, cut off the end and put the plug back of the defective place. Cords frequently wear out too soon because of rough treatment in the hands of operators. An operator should never be allowed to pull out the plug by grasping the cord, neither

should she push the plug into the jack by placing the thumb on the butt of the plug. In putting a plug onto an old cord first commence half way down the cord and pull the braid up toward the end till it is well stretched, then cut off the superfluous braid and wrap a strong thread tightly about it so that it cannot slip back. Now connect the two strands under the proper screws and tie the cord to the base of the plug, if there is such a place for tying, by wrapping with stout thread. There are generally little tips provided to be soldered to the ends of the strands; these are fastened under the screw heads, making a neat and permanent connection.

The reason for stretching the braid on the cord is to prevent too much stress from coming upon the strands. The cords should be tested every morning or evening so as to be sure that they are in good working condition. It is always better to do the mending at night, or, if in a small exchange, during the slack hours. Scratching sometimes occurs in the operator's primary circuit from bad contacts or from worn-out transmitter cords. In this case the connections to the operator's cut-in jack and the springs of the same should be examined. If the trouble is in the cords new ones should be supplied.

Clearing-out drop does not fall. This drop is bridged across the cord circuit and should be of very high impedance, so as not to short-circuit the talking. Examine for open wire connection or open coil. If the drop is short-circuited that pair of cords will also be short-circuited. Examine drop for bad adjustment. Another case of trouble on the clearing-out drop comes from having low resistance subscribers' bells. When ringing off, the subscribers' ringing current is short-circuited, though the bell at the other end and the clearing-out drop fails to act. To cure this trouble put 500-ohm ringers in the subscribers' station, or a lower resistance clearing-out drop may be used. With 80-ohm bells and a 300 or 350 ohm clearing-out drop, there should be no difficulty from the subscriber being "hung up." There is a great deal of mistaken ideas about resistance of clearing-out drops, the majority of telephone men maintaining that they should be of high resistance. It is impossible to detect the difference in the transmission, whether the drop is of 300 ohms or a thousand, if the former is of good design.

WILLIAMS ELECTRIC CO.'S APPARATUS.

The following illustrations show the detailed construction of some of the parts of the improved telephone apparatus of The Williams Electric Company, Cleveland, Ohio.

Figure 1 shows the new style double core ringer which this company is now making. The principal improvement in this ringer over others of its type is in the manner of attaching the cores to the yoke. It will be seen by referring to the illustration (Figure 1) that the cores shoulder on and pass through the yoke and are fastened by means of steel nuts, thus giving them additional magnetic surface and greater mechanical rigidity. The adjustment is effected by moving the armature yoke up and down through the permanent magnet brushing and fastening in position by means of a machine screw. This ringer is wound with the best of silk insulated wire and for the series type is wound to 80 ohms and for bridging work, to resistance of 1000, 1600, 2500 and 3500 ohms.

Figure 2 is a general view of the new switchboard generator manufactured by this company which is claimed to be a very powerful instrument, using a heavy cast cut gear and laminated armature. These instruments are wound to 25,000, 50,000 and 75,000 ohms ringing capacity, and are mounted on hard wood base with two binding posts, so as to make it convenient for attaching to switchboards.

Figures 3 and 4 show detailed construction of the laminated armature which is made up of a large number of soft Norway iron punchings. These punchings are made so accurately that they assemble on the shaft and run perfectly true without grinding or filing. This is a very important point on any laminated armature for grinding or filing destroys the beneficial effects of lamination. Before these discs are assembled on to the shaft they are all thoroughly annealed in a charcoal fire, which makes

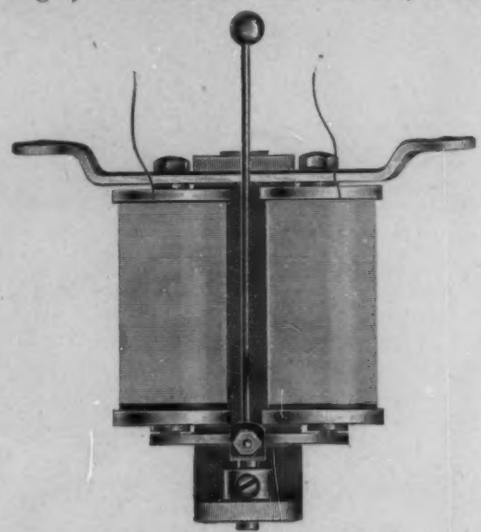


FIG. 1.—NEW TYPE RINGER.

them extremely soft and permeable to magnetic lines. These armatures go into all the switchboard generators and bridging bells made by this company.

This company has recently made some improvement in the construction of their double pole, metal head, hard rubber shell receiver.

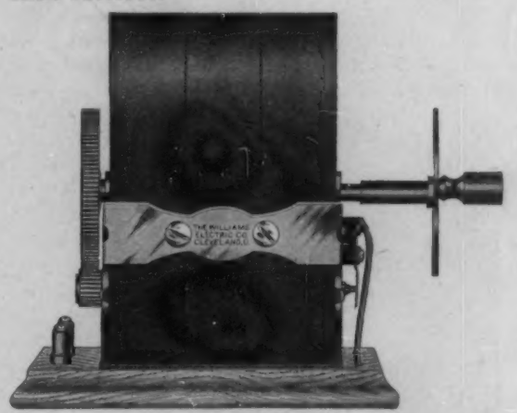


FIG. 2.—SWITCHBOARD GENERATOR.

Figure 5 shows the metal head ready for molding into receiver shell. It is made out of heavy sheet brass, accurately formed and machined and has part of its body formed down, which is molded into the rubber, forming a part

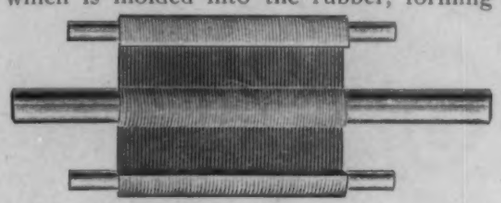


FIG. 3.

of it, which holds it rigidly in position. This is said to be the only concealed metal head, that is really a part of the shell itself, that there is on the market.

Figure 6 shows the interior of the receiver; that is the horse-shoe magnet, spool carrying disc, and the adjusting screws. This disc has three double springs around its periphery that are always pressing upward against the adjusting screws, giving a very rigid form of construction,

making it impossible for these screws to work loose or for the receiver to change its adjustment. The mounting of these cores being so near the diaphragm end of the receiver renders impossible any change in adjustment, owing to changes in temperature.

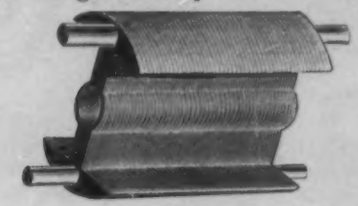


FIG. 4.

FIG. 5.

The permanent magnet of this receiver is semi-circular in sections so as to fit snugly into the receiver shell, so as to allow as much weight of permanent magnet steel as possible within the allotted space. This powerful permanent magnet permits the use of a heavy diaphragm, which when clamped on to the metal head, gives loud speaking and clear articulation.

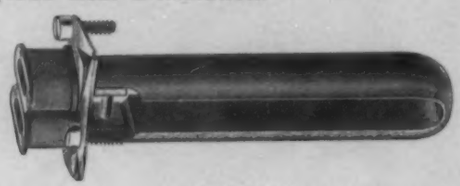


FIG. 6.

Figure 7 shows the general view of the new "Williams" long distance swinging arm transmitter made and used by this company on all of its 'phones. The arm is hollow and has a double cord passing through it. In the base is rigidly mounted a powerful high-grade induction coil especially designed to give best results on long and heavily loaded toll or party lines. These coils are carefully made and every one of them before being used is placed through a talking test of 100,000 ohms. All joints are soldered and no dependence is placed on the swinging arm for electrical connection; as both sides of the circuit are carried by the double cord concealed in arm.

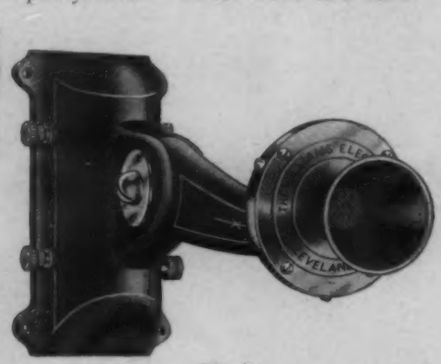


FIG. 7.

FIG. 8.

FIG. 9.

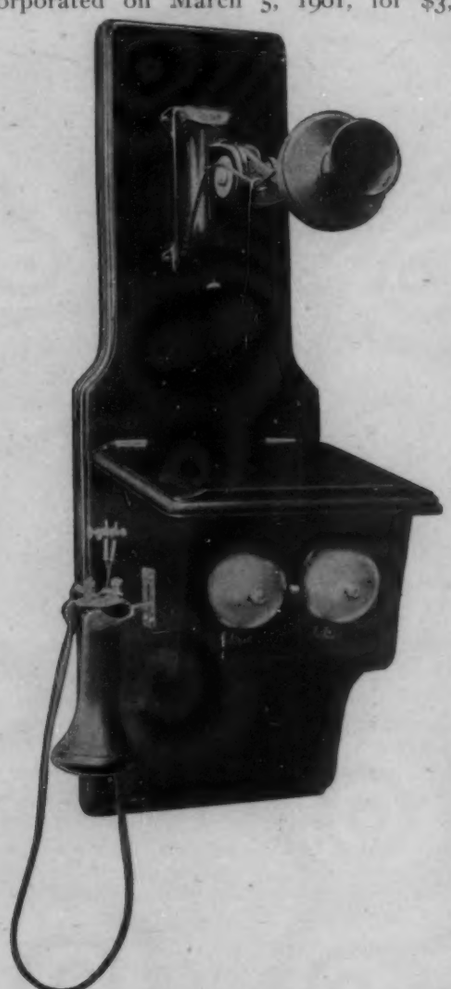
This transmitter is equipped with four lock nut binding posts. The joint between the transmitter arm and base is milled out to receive the arm, which is accurately machined so as to make a nice running fit, so that the movement of this arm up and down is perfectly free and easy, but at the same time sufficiently rigid to remain in any position in which it is placed. The transmitter head, or microphone, that is fitted on to this arm, is of the solid back depressed cushion type that has been so successfully used by this company for the past year. Carbon electrodes of the finest quality are used throughout, which are accurately ground and machined so as to fit snugly into the receptacles provided for them; and are clamped into position by heavy screws, which make an exceptionally good electrical contact with the other parts of the circuit. It is said that this is one of the most sensitive and clear speaking transmitters that there is in the independent telephone field. These instruments are used by some of the largest companies for their heaviest long-distance work. This company has recently added additional machinery and floor space, and is increasing its output so that they are now in shape to fill orders promptly.

Figure 8 shows a complete receiver ready for use. This shell is made of the best hard rubber, and the binding posts are of the spring lock type, making loose contact, between the receiver and cord, impossible.

Figure 9 shows the end view construction of the receiver, showing the adjusting screws, core disc and magnet spools.

A NEW MANUFACTURING COMPANY'S PRODUCT.

The Independent Telephone Manufacturing Company was incorporated on March 5, 1901, for $3,000, and at its first regular meeting the following officers were elected: President and Treasurer, J. J. Comer; Secretary, I. F. Dunwiddie. Mr. Comer was for a number



NO. 30—LONG DISTANCE EXCHANGE TELEPHONE.

of years identified with the Chicago Telephone Company and very recently severed his connections with them to enter the Independent telephone manufacturing field. His intimate knowledge of the standard Bell apparatus will no doubt prove to be of inestimable value to his company

NO. 42—DESK SET.

Mr. Dunwiddie, having been connected with the Publisher's Commercial Union for 20 years, has acquired a knowledge of advertising which makes him a past master in the art. From the start the volume of business was beyond all expectation and to successfully handle it, it was necessary inside of a month to increase the capital stock to $5,000, and acquire additional facilities for the manufacture of telephone apparatus.

NO. 46—INTERCOMMUNICATING TELEPHONE.

On April 10th, the Independent Telephone Manufacturing Company absorbed the firm of Holyoke & Holyoke, who are pioneers in the independent telephone field. The latter have for a number of years been manufacturing for the wholesale trade a complete and staple line of switchboards, telephones and accessories. A number of very valuable inventions have been patented by Mr. J. E. Holyoke, notably those pertaining to self-restoring drops and these patents which cover a wide field are now owned and controlled by this company. The merging of the two companies into one has not only greatly increased their facilities for manufacturing but has placed them in a position to offer to the retail trade the very highest class of apparatus at astonishingly low prices.

The adjacent cuts show three of their standard types of telephones. No. 42 desk set is a facsimile of the latest Bell instrument. In beauty of outline it is unsurpassed and appeals at once to the aesthetic taste of the user of high-grade apparatus. Its internal construction is also of the best quality and in effect is identically the same as the instrument from which it is patterned. No. 46 inter-communicating telephone is one of the most beautiful of its class. It is furnished in nickel and black enamel and presents a most pleasing appearance. It can be furnished in any size from five points up to thirty points. No. 30 is a standard long distance or exchange telephone. On account of its compactness, efficiency and general beauty, it has become a great favorite for residence equipment.

Nothing but the best quality of material and the highest grade of workmanship is employed in the manufacture of their entire line of equipment and they further guarantee it to be free from infringement of existing patents. They now occupy extensive quarters at 224-226 S. Clinton street, Chicago, and are in a position to fill all orders promptly.

HARVARD ELECTRIC COMPANY SPECIALTIES.

The Harvard Electric Company, 224-226 S. Clinton street, Chicago, are one of the most extensive exclusive manufacturers of fuses, fuse blocks, lightning arresters, distributing boards and protective devices, in this country.

In the manufacture of fuses for protection of telegraph, telephone and other sensitive instruments from lightning and other abnormal currents, there are two essentials; first, accuracy, and second, uniformity.

CARBON BLOCK.

The gradual remarkable increase in the business of the Harvard Electric Company is evidence that their goods fulfill these requirements. We illustrate herewith a few types of the well-known Harvard protective devices.

The fuses are made in several lengths in both Western Union and Postal styles, with either foil or copper terminals. All fuses are mounted on mica of proper thickness with either foil-cemented or soldered-copper terminals.

FUSE STRIP.

They recommend the purchase of copper terminal fuses as they are more satisfactory, and although the first cost is higher, they are more economical in the end. Burnt-out copper fuses can be repaired for about one-half of their original cost, while fuses with foil-cemented terminals cannot.

It will pay you to save your burnt-out copper terminal fuses and have them repaired. The lightning arresters illustrated herewith are too well known to need any description. They have a large quantity in stock continually and are always prepared to make prompt shipment.

We illustrate herewith the perfected Harvard Influence and X-Ray machine. This machine is being rapidly adopted by the leading colleges, hospitals, sanitariums, and our most prominent physicians. Being independent of an electric current from the street and generating its own electric sources, it can be operated satisfactory in any locality and is always ready for instant use.

While a good coil produces a good X-Ray it is of no further use in a physician's office. The coil apparatus cannot relieve pain, give tone to the muscular system, regulate the functions of the human organism, produce sleep or regulate the pulse and temperature when functionally deranged.

It produces a brilliant X-Ray, but the physician's office has no further use for it. While the operation of a coil apparatus provided with brake-wheel, motor and rheostat may be simple to an expert electrician it is not so to a busy practitioner. It is expensive and troublesome to keep such an apparatus in first-class condition.

The Harvard machine is the simplest, safest and most convenient method for producing the brilliant and penetrating X-Rays, and it stands out in strong contrast to the complicated and cumbersome coils whose place is in the laboratory of the expert electrician rather than in the office of a busy practitioner.

The Harvard apparatus possesses every advantage which can be attributed to the most expensive coil apparatus without being subject to any of its numerous disadvantages.

The price of these machines is very reasonable provided power, elegance, reliability, efficiency, durability and cost of maintenance are taken into consideration.

Physicians interested in a machine of this character are cordially invited to send for printed matter.

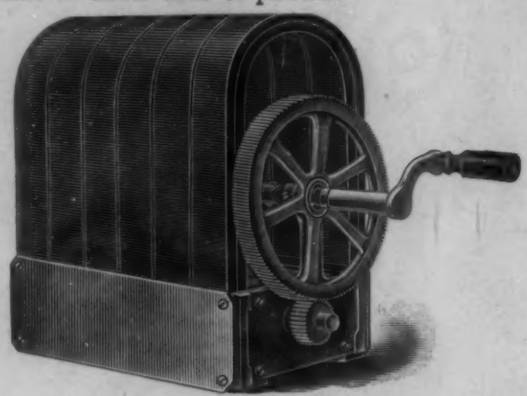
SOME CHICAGO TELEPHONES.

The demand for party line telephones has grown to such enormous proportions that it is probably no flight of fancy to predict that within a few years almost every farmer in the United States will have telephonic connection with his neighbors and the outside world by means of bridging party lines. This class of service has presented new problems for engineering talent. In most instances these problems have been solved in a very satisfactory manner, and the limitations of legitimate bridging work have been sharply defined. For instance, there are many reasons why such lines should not have a large number of stations. The first and foremost reason is because with only a few stations on each division, the relative opportunities for each subscriber to use his instrument are greater than on heavily loaded lines. It is not an uncommon occurrence for a subscriber on a heavily loaded line to find it busy and to have to wait an hour while a conversation is being carried on between subscribers who legitimately belong on another division.

In cases of line trouble, particularly short circuits, a much smaller number of subscribers is inconvenienced when the bridging system is divided into divisions of comparatively few instruments each; further, the work of locating and remedying trouble in such cases is much less than on heavily loaded lines.

In spite of the many advantages of not overloading, the fact remains that there are many reasons why it is inconvenient to divide a line and employ switches for connecting the different divisions.

The Chicago Telephone Supply Company claims it has made a special study of this subject and to be able to supply the wants of either class of patrons.



CHICAGO BRIDGING GENERATOR, NO. 2.

Chicago bridging generator No. 2 is presented as embodying the highest state of the art in heavy bridging work. It is equipped with large laminated armature, which in size is claimed to be larger than any bridging armature on the market, and which is built on strictly scientific lines to accommodate the largest possible quantity of silk magnet wire of the proper gauge. The field magnet consists of twelve powerful magnets placed in two rows of six each. The strength of this magnet is unexcelled in bridging work, on account of the quality of magnet steel used and because it is of the laminated type.

MODEL 25. MODEL 26.

All magnet steel used in generators produced by the Chicago Telephone Supply Company is of the highest grade and is specially treated to insure permanency and the highest degree of magnetism.

Chicago bridging telephone model 25 is designed especially for those heavily loaded lines which it is inconvenient to divide into divisions, and which will have at least twenty-five stations.

This instrument is guaranteed to ring more telephones

than any instrument on the market. It is equipped with Chicago bridging generator No. 2; long pattern bridging striker; solid back transmitter; bi-polar receiver; long-distance induction coil; long lever automatic switch, and will be furnished in any style of cabinet desired.

Toll line companies which place comparatively few instruments on each division will find this instrument of great service at division points. On such systems it sometimes happens that two or more divisions are accidentally left in connection with each other. In such an event, the Chicago telephone model 25, will, it is claimed, easily ring all of the bells on the connected divisions, and thus avoid the annoyance and trouble that frequently arises when a bridging telephone of not sufficient power is used at junction points.

Chicago telephone model 26 is also a new type of Chicago apparatus. It is intended for use in connection with dry batteries and will be furnished for exchange or bridging work as desired. When equipped for bridging work with bridging generator No. 1, it is guaranteed to ring fifteen bells connected in multiple. When equipped with bridging generator No. 2, it is guaranteed to ring satisfactorily over lines having from twenty-five to forty telephones installed thereon.

For more definite information, write the Chicago Telephone Supply Company, Washington and Canal streets, Chicago.

KELLOGG SWITCHBOARD AND SUPPLY CO.

The Kellogg Switchboard & Supply Company, Chicago, reports a steady increase of business in all departments. A few months ago 10,000 square feet of additional floor space was added to its already large and well equipped factory, and arrangements have been recently made for the addition of 21,000 more. This will be equipped with the most modern machinery, and will facilitate the handling of orders with even greater promptness than heretofore.

The small switchboards of the "Express" type, which this company recently put on the market, have proven very popular and are in great demand, orders for over fifty having been received since March 15. In order to meet the demand for silk and cotton covered wire and switchboard cable, the insulating department has been increased to double its former capacity, and is prepared to fill orders for any size or kind of silk and cotton covered wire on short notice.

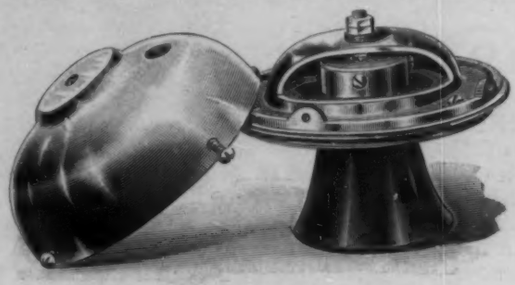
The company also announces that it owns 90,000 of the finest cedar poles in Michigan, which it is prepared to supply in carload lots at lowest prices.

Among the orders for small switchboards, varying in size from 50 to 300 lines each, recently received, are the following: Williamsburg, Pa., Russell, Ia., Somerset, Pa., Chrismaw, Ill., Webster, S. D., Grandbury, Texas, Westchester, Pa., Bartelsville, I. T., Bishop Hill, Ill., Woonsocket, S. D., Tama, Ia., Royersford, Pa., Columbus Junction, Ia., Little Rock, Ark., Marco, Ind., Shawnee, O., Canadian, Tex., Troy, Ind., Savannah, Ill., Chadwick, Ill., Black River Falls, Wis., Astoria, Ill., Concordia, Kan., Ashland, Ky., Blue Rapids, Kan., Greenleaf, Kan., Huntingburg, Ind., Virginia, Ill., Logan, Kan., Hurley, S. D., Sparta, Ill., Miltonville, Kan., Scandia, Kan., Streitsville, Ohio, Lexington, Miss., Story City, Ia., Versailles, Mo., Dalton, Ohio, Doylestown, Pa., West Grove, Pa., Westphalia, Ind., Linton, Ind., Clifton, Kan., Sandborn, Ind., Estelline, S. D., San Francisco, Cal., Joy, Ill., Blue Earth, Minn., Augusta, Ill., Sullivan, Ind., Dawson, Minn., Wellsboro, Pa.

THE INTERNATIONAL SPECIALTY COMPANY has opened new offices at 1005 Monadnock block, Chicago, and will accept contracts for any kind of wood or metal work, and for electrical specialties and supplies. The company has a very large factory and is prepared to fill orders promptly.

SWEDISH-AMERICAN APPARATUS.

Among the new apparatus recently placed on the market by the Swedish-American Telephone Company, Chicago, is a combined telephone and toll board, which is meeting with very large sale. The illustrations show this combined telephone and switchboard, as well as the company's



SWEDISH-AMERICAN TRANSMITTER.

late model telephone, number 100, and its new transmitter, for which many points of superiority are claimed. The carbon receptacle is of metal, with cylinder of metal and mica diaphragm, absolutely insuring against any moisture from

TOLL BOARD. NO. 100—TELEPHONE.

the breath coming in contact with the carbon elements. This transmitter is said to be the only one in the Independent field that does not have any fabric in its construction. The company will send full description and prices of its different kinds of telephone apparatus upon request.

A VIEW OF CORPORATIONS FROM THE STANDPOINT OF THE STOCKHOLDER.

BY GRANT NEWELL.

Article 5.

The liability of persons, whether natural or artificial, in the law, is twofold in its nature. First, one becomes bound to perform some obligation, because he has consented to be so bound, either expressly or by implication. And this is what the law terms a liability *ex contractu*, that is, arising out of a contract. With regard to this liability, it is to be said that corporations are to be governed by the same rules of law as are applied to individuals, with the important exception of the effect of the doctrine of ultra vires, and this doctrine has its origin in the fact that artificial persons lack that complete power of action with which natural persons are endowed as a matter of law. So that there are certain obligations into which a corporation has no power to enter, and by which it cannot bind itself, no matter how great may be its inclination so to do or how formal an instrument it may execute to evidence such intention. For instance, a manufacturing corporation would not be bound as surety upon the indemnity bond of an individual, even though it executed the bond in the most formal and legally exact manner, and this is true, because, to become such surety is beyond, or without its powers, that is, ultra vires. The other form of liability arises from the general obligation which the law imposes upon all persons, whether natural or artificial, to conduct and manage their affairs in such a manner that they shall not infringe upon the rights of any other person while in the lawful conduct of his own concerns. And this obligation rests not upon the consent of the individual, either express or implied, but is imposed by the law for the government of all. When one violates an express provision of the law, unconnected with contractural rights, he commits a wrong. If this wrong be of such a nature as to imperil the safety of the public at large, the wrong-doer is guilty of a crime, but when of such a nature as to affect the rights of a certain individual, or class of individuals only, he is guilty of what is called in the law "a tort," that is, a wrong. And when one is guilty of a tort his punishment is enforced, not by the people at large, but by the individual whom he has wronged, and the law will compel him to make reparation by assessing damages against him and in favor of the injured party. This liability, or right of action, is called *ex delicto*, because it arises out of a wrong. It is not to be understood that crimes or criminal liability is herein referred to, for the state alone has the power to inflict punishment for crime. It is quite interesting, however, to note in this connection that there are certain crimes which even a corporation can commit. But, inasmuch as a corporation, in the language of Lord Coke, "hath neither soul to damn nor body to kick," the crimes capable of being committed by it are limited to those which are punishable by fine only, for it is manifestly impossible to imprison, or to inflict the death penalty upon a corporation. Crimes may for our present purposes be divided into two classes—felonies and misdemeanors, the former being punishable by deprivation of personal liberty, i. e., imprisonment in the penitentiary; the latter by imprisonment in the common jail, or a fine, or both. Hence it appears that corporations are liable criminally, only for the commission of misdemeanors. Yet it is to be said that so severe is the punishment visited upon the corporation for violation of particular statutory provisions in certain states that, though the courts have no power to hang, or to electrocute, this artificial person, they may, nevertheless, bring its existence to an end by forfeiting the charter under which it exists, an operation financially painful to the shareholders, if not physically so to the artificial personality of the corporation. Every crime of the degree of a felony is also a tort, but every tort is not a crime, for to constitute it a crime the offense must have been committed against the peace and dignity of the people at large, while a crime is a wrong suffered by some person or persons in their capacity of private citizens. Torts may be committed against either the person or the property. Thus, if I negligently toss some heavy article from an upper window into the highway and it fall upon the head of one driving thereon in his carriage, I am guilty of a tort to his person, for I have injured him therein, but if the article fall upon the horse and it suffer harm therefrom, I have committed a tort against the property of the owner of the horse. This much has been said by way of introduction, for it is the purpose of this article to treat of the liability of telephone corporations for injuries to property, and here the reader is asked to note the distinction made in the law between the words "injury" and "damages." The law under certain circumstances, as in the case of eminent domain, expressly sanctions the latter, contemplating that anything that is done on or upon one's land without his consent results in damage to him. But when these damages have been ascertained in the manner provided by law and the owner compensated therefor, he has suffered no injury as a matter of law or for which he may have legal redress. Injuries afford foundations for actions at law; damages are the compensation which the law awards to the injured party. From what has been said, it will be perceived that injury to the property of others by the class of corporations now under discussion arises much more frequently *ex delicto*, that is, from wrongs unconnected with contracts, than from injuries growing out of the violation of contractural relations. But the distinctions, clearly defined as they are in theory, ofttimes in practice so shade into one another that it is a matter of the greatest difficulty to determine where the one ends and the other begins. To illustrate: If a telephone company makes an agreement with the owner of a piece of land, whereby, for a certain compensation, it is permitted to place its poles at points upon the land definitely settled and fixed, and afterward proceeds to erect such poles at points and places other than those fixed upon, the company has violated the contract, for which breach the landowner may maintain a suit, and has also committed that kind of tort, or wrong, technically knows as "a trespass," for when one has license to go upon the land of another, to make use of it in a certain way or for a certain purpose, he loses the protection of the license and is upon the land without right; in other words, he is a trespasser. Hence, in a case of this kind, the landowner might elect which remedy he would pursue to recover the damages sustained; he is at liberty to sue upon the contract for the breach thereof, or to bring action against the company for trespassing on his land. Again, in actions arising out of contract, the one complaining is bound only to prove that the contract existed, the breach thereof by the other party and the amount of damages suffered by him in consequence thereof; the reason why the breach was committed—so long as it came about through the action of the other party—is wholly immaterial. The defendant cannot excuse himself from the performance of his part of the contract by showing that he did all that he considered necessary, for if his acts have fallen short of complete and full performance, he is guilty of a breach, and liable in law for the natural and necessary consequences thereof. But in actions *ex delicto* the actions and conduct of the defendant are of prime importance at every stage of the proceedings, and he may generally excuse himself by showing that his conduct in the affair was that of an ordinarily prudent and skillful person under like circumstances. Furthermore, in actions *ex delicto*, the liability of the defendant always arises either from misfeasance, malfeasance, or nonfeasance, by which is meant, (1) the doing of a lawful act in an unlawful manner, (2) the doing of an unlawful act in itself, and (3) the failure to perform some duty with which he was charged as a matter of law. The first and third propositions give rise to those extensive rules of law which center about the question of negligence, while in the second we find that class of torts which approaches most nearly to crime, that is, of intentional wrong-doing. For example, a telephone company,

having the right to erect its poles along a highway, does the work in so careless a manner that some of them fall and obstruct the passage of traffic; here the company is guilty of a misfeasance, i. e., the doing of a lawful act in an unlawful manner. Again, it may be the duty of the company to provide certain appliances for the protection of the premises of its subscribers from loss or damages by fire communicated by its lines; it fails so to do, and loss occurs by reason of such failure; the company is guilty of a nonfeasance, in that it has not performed the duty incumbent upon it. And in both of the above instances the question of the care exercised by the company is the principal one for determination. Negligence is a negative term and is made use of to express the lack or absence of that degree of care which the law requires to be exercised under the circumstances of the particular case. But when a man wilfully and maliciously, or with the exercise of so little care that it amounts to a wilful disregard of the rights of others, does an act, and such act results in an injury to another, without that other's fault, he is guilty of a malfeasance. Of such torts as this may be mentioned trespass, assault and battery, slander and libel, etc., from which enumeration it will be seen that the class of individuals under consideration are seldom called upon to defend themselves for malfeasance, except, perhaps, in the single case of trespass. The general rule is that corporations, within the scope of their powers and abilities, though acting, of course, in every case through their agents or servants, are liable for their torts under the same circumstances and to the same extent as are natural persons. Having now made such explanations as seem necessary to an understanding of what is to follow, the next article will endeavor to show, by a discussion of certain cases, how the courts have determined some of the important questions touching the liability of telephone companies for injuries inflicted upon or to the property of others.

PEOPLE'S TELEPHONE COMPANY.

The People's Telephone Company of the city of Detroit, Mich., have let contracts for the construction of its telephone exchange system and contemplate the erection and equipment of the largest single multiple switchboard and central office equipment ever installed in the United States. This contract was awarded to the Stromberg-Carlson Telephone Manufacturing Company of Chicago, after a thorough investigation of the various apparatus manufactured by the Independent telephone manufacturers.

The initial switchboard equipment calls for a switchboard to have a capacity for 14,400 subscribers' lines of the multiple lamp line signal central energy type, equipped for the immediate operation of 6,000 subscribers' lines, with complete power, battery and ringing epuipment in duplicate, with a capacity sufficient for the complete operation of the full ultimate capacity of the switchboard and 6,000 telephones.

The Stromberg-Carlson system is already in use in Rochester, N. Y., St. Paul and Minneapolis, Minn., Boston, Mass., Youngstown and Akron, Ohio, Camden, N. J., Duluth, Minn., Waco and San Antonio, Texas, Lexington, Ky,. Wheeling, W. Va., and a great many other smaller cities in the United States.

"We placed our order just in time," said Mr. Ware, "to get in ahead of Philadelphia and other eastern and southern cities, where new telephone companies are figuring with the Stromberg-Carlson people. In fact, we hurried our order to be sure of having our work done first. The installation date specified in the contract is February 1, 1902."

The People's Telephone Company, after a careful search for adequate headquarters, decided that they could only obtain what they wished by buying a site and erecting an exchange building, and accordingly purchased a lot 80x90 feet, located on the southwest corner of Park and Elizabeth streets. This company's engineers have figured out that this site is within 200 feet of the telephone center of the city. The building will be six stories in height, modern in construction and especially designed for use as a telephone exchange. This building is favorably situated, so that it will receive light from the north and east sides and afford excellent opportunities of bringing the very large and complex conduit system into the building without conflict with the existing conduit systems of other companies. The engineering problem for the installation of such a large system has been very credibly worked out by their consulting engineer, Mr. Maxinie Reber of Cleveland, Ohio, who has had very large experience in the construction and operation of some of the largest exchanges in the United States.

The underground material will be supplied by the Standard Underground Cable Company of Pittsburg. The contract was made at a certain price per foot, the material to be delivered as called for. The work of underground construction will be commenced at once.

The contracts for other materials have not yet been awarded. "These can be obtained in the market at almost any time," says Mr. Ware; "the chief idea has been to get contracts placed on the work that requires time. It has been fully determined that only copper wire shall be used, making the entire Detroit system one of metallic circuit."

The People's Telephone Company's Detroit Exchange will be the model exchange in the United States. It is to accomplish this that they have decided to install an all-copper wire service and to concentrate all our lines in one big exchange building. In this concentration of lines alone we shall be able to save time for our subscribers and largely increase the efficiency of the service. We do not believe at all in the branch station system. The Stromberg-Carlson Telephone Manufacturing Company will endeavor to make this Detroit exchange the model exchange of the United States for the reason that the city of Detroit is central and has many visitors and will be a showroom for them, so to speak. Everything about the construction will be permanent and with a view to the accommodation in the not distant future of the entire 14,400 subscribers' lines, for which the exchange is being built and designed to accommodate."

HOW TO MAKE A DRY BATTERY.

Mr. William Roche of New York, a well-known manufacturer of dry batteries, gave the following method in "The Telegraph Age" for making a dry battery at home:

"First make a zinc cup, than roll a cup or tube of blotting paper, about three or four turns, to fit tight inside of the zinc cup, and pour in the bottom of the cup about two tablespoonsful of hot melted pitch or rosin, to insulate the bottom of the cup. Next make your solution. This is done by dissolving five ounces of sal-ammoniac in one pint of clear water. When so dissolved, add seven ounces of granulated chloride of zinc. Stir thoroughly till dissolved, and continue stirring every few minutes for one hour or more. The solution is then ready for use.

"The manner of making a negative or carbon element is to mix eight ounces of powdered black oxide of manganese and sixteen ounces of powdered carbon thoroughly together, and dampen or moisten with five fluid ounces of the solution. If the carbon and manganese are very dry, you may need a little more solution. All that remains now to complete the cell is to soak the blotting paper inside of the zinc can thoroughly with the solution; fill the can about three-quarters full and let it stand a couple of minutes; then pour out the solution, place your carbon plate in the center of the zinc can and pack in your carbon element good and hard. The packing will probably force a little of the solution up the paper by compression, but that will not injure the cell any. When the powdered elements are wet enough, clean away all particles of the carbon element from the top of the paper and zinc can, so that there will be no internal short circuit; seal your cell, and when you have your connectors on the cell is ready for use. This formula will produce a cell from 20 per cent. to 50 per cent. better than most of the dry cells of the present day."

TRADE NOTES.

J. J. REIDY, New Haven, Conn., reports that the war department has just shipped nine boxes of the Donnelly climbers and straps to the Philippine Islands.

THE BUTLER-TAYLOR COMPANY of Ravenna, Ohio, has just issued a circular, describing its new automatic lightning arrester, which will be sent upon request.

THE MOON MANUFACTURING COMPANY reports a large business this season, and will be pleased to furnish full information to anyone interested in the Moon terminal head, etc.

THE GARTON-DANIELS COMPANY, Keokuk, Iowa, has just published an attractive booklet, No. 28, giving a complete description of the Garton lightning arresters. Same will be sent upon application.

THE ACME ELECTRIC COMPANY, Chicago, has just issued a new catalogue, giving a complete description of its apparatus. The catalogue is gotten up in very nice form and will be mailed to anyone wishing it.

THE ERICSSON TELEPHONE COMPANY, New York City, states that the war department has ordered several telephones of Ericsson make, which are to be shipped to Manila. The company reports a large business.

THE DEARBORN ELECTRIC COMPANY is now located in the new Electrical building, Chicago, and has just issued an attractive catalogue, No. 20, which will be sent upon request. The company reports a fine business.

THE INDEPENDENT TELEPHONE SUPPLY COMPANY has just issued a booklet, giving description and prices of its different telephone specialties. Same will be sent upon application, as will also an attractive souvenir.

THE STANDARD CONSTRUCTION COMPANY has recently moved to its new factory at 90-98 Market street, Chicago. It has just issued a new catalogue, No. 17, giving a complete description of its apparatus. Same will be sent upon request.

THE AMERICAN ELECTRIC TELEPHONE COMPANY, Chicago, has again been obliged to enlarge their factory, and has secured the adjoining building. Mr. P. C. Burns, the president of the company, reports a very large business this season.

MR. C. W. SCOTT of Lynchburg, Va., has recently secured a patent on a new electric switch, by means of which conductors can be quickly detached from a switchboard in case of emergency or on the approach of a storm. His advertisement appears in this issue of TELEPHONY.

W. H. HYDE & CO. of Milwaukee, Wis., have just published a telephone inspector's handbook, entitled "Telephone Troubles and How to Find Them." This book contains much useful information, and will be sent to any address upon receipt of the price, twenty-five cents.

THE INDEPENDENT TELEPHONE MANUFACTURING COMPANY, 224 South Clinton street, Chicago, has just issued a very attractive wall poster, giving cuts of their apparatus. It will send same to anyone desiring a copy.

THE ILLINOIS ELECTRIC COMPANY, Chicago, has just issued a pamphlet giving a description of its bridging and series telephones; also a net price list, No. 14, of telephone apparatus and construction material, which it will be pleased to send upon request. The company reports a large business this season.

THE CENTURY TELEPHONE CONSTRUCTION COMPANY of Cleveland, Ohio, reports a very great demand for its regular exchange and bridging telephones, fitted with high-grade Century transmitter. It also has orders for several central battery, multiple switchboards, all of latest design, and has just shipped a 1,200-line capacity multiple switchboard, equipped with electric light line signals, and with full supervision in the cord circuit, to Hornellsville, N. Y. It also reports a great demand for inside and outside terminals, illustrated in its advertisement this month.

W. N. MATTHEWS & BRO., St. Louis, Mo., report large sales for the Stombaugh hand anchors, and have received many complimentary letters in regard to the same—one being from the Northwestern Indiana Telephone Company of Valparaiso, Ind. They will send catalogue upon request.

THE EUREKA ELECTRIC COMPANY, Chicago, has opened an eastern office at 580 Ellicott Square, Buffalo, N. Y., under the management of Messrs. George B. Pratt and I. C. Woodford. The company also has large space in the Electrical building in the Pan-American Exposition grounds.

PERSONALS.

Mr. Stephen L. Coles, who recently resigned as managing editor of the Electrical Review, of New York City, after twelve years' service with that journal, announces that he has associated himself with Mr. M. J. Shaughnessy, of New York City, in the business of preparing and publishing technical and trade literature and advertising for manufacturers and others who wish really helpful assistance in such matters. The relation between these gentlemen and their clients is very similar to that between lawyer and client. Mr. Shaughnessy is well known among general advertisers. He organized the advertising department for John Wanamaker when the latter began business in New York City. He also prepared and placed advertising for the first Electrical Show at the Grand Central Palace, New York, in 1896, which will be recalled as a great success. Mr. Coles has many warm friends and acquaintances in the electrical and allied industries. Through his long experience in technical journalism and other newspaper work he is thoroughly posted as to the needs of manufacturers and others seeking the widest and best publicity for their product. Messrs. Shaughnessy and Coles are established in Temple Court, 5 Beekman street, New York City, where the friends of both will be welcome.

According to the New York "Commercial," the fate of the Erie telephone system, control of which is now held by the Old Colony Trust Syndicate of Boston, which interests are friendly to the Bell, is a matter of considerable speculation. It has been reported that the Telephone, Telegraph & Cable Company of America would attempt to regain the control lately surrendered. The officials of the independent company deny this. President Wilson of the Telephone, Telegraph & Cable Company says: "No official knowledge of the authorization of the purchase of the Erie Telephone Company to the Telephone, Telegraph & Cable Company of America exists." Erie stock has been steadily advancing in the market. The Telephone, Telegraph & Cable Company still holds 21,000 shares, and it is by no means a small factor in the future of the Erie. Bell interests are suspected of an attempt to depress the stock, but if they sought to do this they have failed, hence the source of recent buying is more mysterious than ever.

That the Bell monopoly is making money may be inferred from the fact that Frederick P. Fish, its newly elected president, is to receive a salary of $100,000 a year. Might it not be a good idea to reduce rates slightly and salaries proportionately?